The Blast Furnace and Steel Plant

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Steel Direct From Ore

IN many instances a study of the history of steel making reveals the fact that we move in cycles. Some process, having certain intrinsic values is adopted, or at least is put on trial, but after a period of months or years is abandoned in favor of some other process which assures immediate and greater economies or improvements in operation. It frequently happens that the process abandoned fails to find favor only because a weakness is discovered which, although minor, is serious enough to discourage its retention.

Years pass until finally some ambitious investigator happens upon the description of the forgotten process. Attracted by its apparent merits and simplicity, he seeks to overcome the defects and establish it as a successful and going process. This he may do especially, if in the interim between its abandonment and its reclaimation, there have been advances in the field of engineering or metallurgy which, when made part of the old process, will remove its defects. In other words in the light of present day science, projects which in former days were not feasible may be rehabilitated and prove a greater success than those now in service.

An example, analogous to this, is the direct process of producing steel. Back in the early years of steel making the Catalan forge was the only means of making a hybrid steel—part high and part low carbon—but its product and its manufacture were so uncertain that it was discarded. Today, after a lapse of some hundreds of years, production of steel by the direct process is again attracting the attention of the steel makers and, with the aid of science, there is the possibility that a new era may dawn, and our blast furnaces, open hearth furnaces and Bessemer converters may eventually go the way of the Catalan forge.

Charles M. Schwab Elected President of the Iron and Steel Institute

THE thirty-second general meeting of the American Iron and Steel Institute was notable in that Charles M. Schwab was elected president to succeed the late Elbert H. Gary. Mr. Schwab is the second president of the institute inasmuch as Judge Gary held that position from the day the institute was formed until his death. James A. Farrell, president of the United States Steel Corporation was chosen a vice president to succeed Mr. Schwab and Willis L. King and John A. Topping were re-elected as vice presidents.

Mr. Schwab's election was consumated at a meeting of the board of directors of the institute held on the afternoon of October 27 at which meeting he was nominated by James A. Farrell, president of the United States Steel Corporation.

At 10:00 o'clock on the morning of October 28 the meeting of the institute was called to order by E. A. S. Clarke, secretary who then handed the gavel to Mr. Farrell. In introducing Mr. Schwab as president Mr. Farrell said:

"I now have the pleasure of introducing to you the most outstanding figure in the industry, a man who needs no introduction, a man who is loved by all and a man whom we know will carry out the policies which have always permeated this great organization, Charles M. Schwab."

Mr. Schwab's welcome, by the 2,000 members in attendance, was so enthusiastic that it was several minutes before order could be restored. When quiet again prevailed the new president introduced an innovation by inviting the directors of the institute to sit on the platform with him. Those that responded were Willis L. King, Samuel Mather, E. J. Buffington, E. G. Grace, L. E. Block, James A. Campbell, A. C. Dinkey, E. A. S. Clarke, James A. Farrell, William J. Filbert, Horace A. Wilkinson, Isaac M. Scott, Samuel E. Hackett, William H. Donner and Severn P. Ker. Two of the directors, Willis L. King and James A. Campbell were then requested to address the meeting after which Samuel Mather one of the oldest directors of the institute was presented.

Mr. Schwab in his remarks stated that: "We are going to start with complete co-operation in every way, from the head down. And so what I have to say with reference to business conditions will be, as nearly as I can express it, the combined ideas or the individual ideas assembled of the board of directors of the Iron and Steel Institute."

He then mentioned the fact that he was accused of always being optimistic to which accusation he replied:

"I have been an optimist, and I am afraid I cannot change. I do not think that I have been wrong in my optimism over these past 45 years. In 1886, when this country made 2,600,000 tons of steel, I believed it was going to grow; it doubled the next 10 years and doubled each succeeding 10 years, until today for the fifth time it has doubled, and we are making over 40,000,000 tons of steel. In my wildest optimism I never was more optimistic, and therefore I offer no apology to this American Iron and Steel Institute for my optimism in the past, nor do I offer my apology for my optimism for the iron and steel business in the future. Whatever depressions may come at times and whatever lack of business, I still feel that the forward and onward trend in the development of our business is assured."

The president then referred to the distinguished service rendered the institute by Judge Gary in whose memory he suggested a tablet be prepared and placed in a suitable location. This suggestion was unanimously carried.

Mr. Schwab's concluding remarks were:

"I thank all the members of the institute. And be assured that the old man, the farmer from the Allegheny mountains, the ex-steel-maker, will devote the best that is in him to the carrying out of the broad principles of this institute with all the energy that a man of my old age is capable."

The first paper on the program was delivered by S. M. Kintner of the research department of the Westinghouse Electric & Mfg. Company. His paper was entitled: "Knowles Glow Tubes and Similar Recent Developments." Mr. Kintner's paper was an exposition on the vacuum tube as used in radio sets. It was by means of this tube that Judge Gary from his desk in New York was able to set in motion the mills at the Homestead plant of the Carnegie Steel Company, some months ago.

Following Mr. Kintner, W. A. Forbes, assistant to the president of the United States Steel Corporation, presented a paper on technological problems of the Steel industry. Mr. Forbes touched upon the problems which today are of special interest in the manufacture of steel.

Mr. D. L. Mekeel, chief engineer, Jones & Laughlin Steel Corporation, read a paper on "A Steel Mill Boiler Plant." This paper will be found in this issue of The Blast Furnace and Steel Plant.

The afternoon session convened at 2:00 P. M., and was opened by Stephen Badlam, consulting engineer, Pittsburgh, Pa.

"The Evolution of the Wide Strip Mill" was the subject chosen by Mr. Badlam who pronounced the outstanding achievement of the present decade to be the development in the art of rolling wide thin sections as exemplified by the wide strip mills and the continuous sheet mill.

"Behavior of Coke in the Blast Furnace" by T. L. Joseph, supervising engineer, Bureau of Mines, Minneapolis, Minn., was the second paper at the afternoon session. Mr. Joseph's paper appears in full on the following pages of this magazine.

The concluding paper of the meeting was delivered by James T. MacKenzie, metallurgist of the American Cast Iron Pipe Company. The subject was "Cast Iron Pipe Centrifugally Made in Sand Molds." As the ar of centrifugally casting metals is a topic of much concern to engineers this paper was listened to with much interest.

The banquet was attended by about 1600. Addresses were made by Julius H. Barnes, Dr. Virgil Jordan and James A. Campbell, president of the Youngstown Sheet & Tube Company.

Behavior of Coke in the Blast Furnace*

Heat Generation and the Efficiency of Combustion Form the Basis of This Discussion. Considerable Information Was Secured from Experiments Conducted on a Miniature Furnace

By T. L. JOSEPH†

FURNACE operators often find it difficult to relate the physical and chemical properties of coke to its behavior in the blast furnace, and as a result no satisfactory standards of coke quality have been developed. The failure to define clearly the properties of coke is no doubt partly responsible for retarding progress in correlating some measurable property of the coke with its performance in the blast furnace.

Meaning of Combustibility

Perhaps no term has appeared more often in the technical literature referring to coke quality than "combustibility." In 1914, Brassert,[1] in referring to coke quality, stated:

> "It has been recognized that an open-cell structure favors rapid combustion, whereas a dense structure retards it. Since the speed of combustion primarily affects the furnace practice, it appears that the combustibility of cokes should be considered a foremost quality."

Brassert distinguished a fast-burning coke from a slow-burning coke as follows:

> "With fast-burning coke, each molecule of oxygen in the air immediately finds its molecule of carbon in the tuyere zone, and the combustion takes place rapidly and with great intensity. By thus concentrating the combustion in a comparatively small area, the highest heat effect is obtained. With a slow-burning coke, on the other hand, the molecules of oxygen are not able to combine immediately with their molecules of carbon. The result is that combustion is carried higher up in the furnace, the heat is spread over a larger area, and the top temperature increases."

Howland,[2] in 1917, stated:

> "That the most desirable thing about a coke is that quality in the carbon which will allow its being instantaneously burned to CO and thus result in the maximum concentration of heat where needed."

Korevaar[3] relates combustibility with the size of the combustion zone as follows:

> "With constant air and furnace factors the most combustible carbon has the smallest zone of combustion and, in consequence of the law of heat compression, the highest temperature."

Sperr and Jacobsen,[4] in reviewing the work of Koppers, refer particularly to the merits of a fast-burning coke and state:

> "In Koppers' opinion, the blast furnace should not be operated as a gas producer, but should be operated in such a way as to use the minimum quantity of fuel required to reduce the ore and produce iron of good quality. This is best accomplished by the use of a fast-burning coke. With such a coke, a minimum quantity of air is required and so less gas is needed for heating the blast and less power is needed for the blowers per ton of pig iron and the producing capacity of the blast furnace is increased."

These men[5] further expressed their idea of combustibility as follows:

> "In the blast furnace process, the time element is fixed and if we wish to achieve improvement we must act on the fuel and provide that quality which makes possible the desired result. In this case, the desired result is the rapid conversion of carbon dioxide to carbon monoxide. The necessary quality is combustibility."

It is evident that they refer to reactivity toward CO_2 as a measure of combustibility.

On October 5, 1926, a round-table conference on coke was held in Pittsburgh under the auspices of the American Institute of Mining and Metallurgical Engineers. From the discussion which took place it is evident that the term "combustibility" has been given a broad meaning and has been used to cover all the good, as well as the undesirable, qualities of blast-furnace coke. As a result of the diverse opinions expressed, no decision was reached as to what is meant by the combustibility of coke.

Sweetser[6] has proposed the following definition:

> "The combustibilty of a blast furnace coke is the rate of complete gasification of that particular coke in front of the tuyeres of a blast furnace, under standard conditions of blast temperature and of blast volume."

Read[7] has modified Sweetser's definition as follows:

> "The relative flammability of blast furnace coke is indicated by the relative rate of complete gasification of that particular coke in front of the tuyeres of a blast furnace, and can be measured by comparing it with the rate of gasification of a standard coke, both under standard conditions of blast temperature and of blast volume."

Foxwell and Wheeler[8] state that:

> "The combustibility of a coke may be defined as that property which determines its rate of reaction with pure oxygen or with air at a given temperature."

The most recent statement which has come to the writer's attention was made by Lose[9] who defines combustibilty as follows:

> "The rate at which coke is burned to CO_2 by the oxygen of the blast and this CO_2 later converted to CO by the incandescent coke farther from the tuyeres has been generally considered a variable, dependent mainly upon the character of the coke and this rate has been termed the combustibility of the coke."

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*Paper delivered at meeting of Iron and Steel Institute, October 28, 1927.

†Supervising engineer, North-Central Experiment Station, United States Bureau of Mines, Minneapolis, Minn.

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Methods of Measuring Combustibility

Inasmuch as the various methods proposed to determine the relative combustibility of various cokes give an insight into the conception which various investigators have had of this property of coke, a brief discussion of these methods will be given. Most of those devised to measure combustibility consist essentially in determining the loss of weight in a fuel bed after a supposedly equal quantity of air has been forced through the test bed. The comparative loss in weight indicates the relative combustibility of a particular coke. A modification of this method consists of burning samples of coke in a steel cylinder under natural draft and noting the loss in weight. The use of natural draft, rather than a measured amount of air, introduces another variable and makes the method, at best, a qualitative one.

The method used by Koppers[10] is similar to the first one given except that the flame at the top of the cylinder, in place of loss of weight, is taken as a measure of combustibility.

Le Chatelier[11] has proposed to measure combustibility as follows:

> "In a porcelain tube of 4 to 5 cm. diameter, a mass of carbon in small pieces of definite size is placed between two lumps of asbestos, quite filling up the section of the tube; in the middle of this mass a thermometer is placed, and the whole is heated in a furnace to 150 deg. C. When this temperature is reached, the air current is admitted with a definite velocity. . . . In the case of very slow-burning carbon, the temperature will fall fast during the passing of the cold air, and it will remain stationary at a temperature which will be lower the less combustible the carbon; if the carbon is of average combustibility the temperature will rise more or less above 150 deg., and become fixed at a new constant temperature. Finally, if the carbon is very combustible, the temperature will rise rapidly till the carbon is burning fast. It must be understood that, for obtaining comparable results, it is necessary to use the same size carbon and the same velocity of the air current always."

TABLE I

Test of Speed of Combustion of Coke Relative to the Effect of Coke Size.*

Kind of coke	Amount charged Lbs.	Coke consumed Lbs.	Residue Lbs.	Gas Analysis		
				CO %	CO_2 %	O_2 %
Clairton, natural size	100	47.0	53.0	12.4	9.6	0.8
Clairton, natural size	100	43.5	56.5	18.8	7.2	0.8
Clairton, crushed to through 1½-in. scr'n	100	57.0	43.0	20.8	4.0	0.0
Clairton, crushed to through 1½-in. scr'n	100	59.5	40.5	23.8	2.4	0.1
Clairton, crushed to through 1-in. screen	100	65.5	34.5	22.0	1.6	0.2
Clairton Domestic coke†	100	63.5	36.5	22.8	5.6	0.0
Clairton Domestic coke†	100	63.0	37.0	27.6	2.0	0.0

*Lose, J. E., "Operation of Large Hearth Furnaces Using Coke Made from 100 per cent High-Volatile Coal," paper presented before May, 1927, meeting of Amercian Iron and Steel Institute (see Table C, p. 15.)

†Domestic coke averages about 1¼ in. in size. All samples were thoroughly screened over ½-in. screen.

Fischer[12] has proposed a method based on the power of coke to reduce CO_2 to CO, and uses the lowest temperature at which the reduction of CO_2 to CO begins as a measure of this power. Lose[13] has used a method similar to the one first described, to show the effect of size upon combustibility. Inasmuch as his results giving the analyses of the exit gases illustrate a fundamental principle which applies to many of the types of methods described, they have been repeated in Table I.

The gas analyses reported by Lose show some discrepancies. According to the first analysis recorded in Table I, 100 cu. ft. of the exit gas contained the equivalent of 16.6 cu. ft. of O_2 in combination as CO, CO_2 and existing as free O_2

$$\left(\frac{12.4}{2} + 9.6 + 0.8\right).$$

There were approximately 77.2 cu. ft. of N_2 in this same volume of top gas. (Per cent N_2 obtained by difference equals 77.2.) The air used to generate 100 cu. ft. of such gas contained 20.5 cu. ft. of O_2 since the ratio of O_2 to N_2 in air is about 0.266

$$\left(\frac{20.8}{79.2} = 0.266\right) 77.2 \times 0.266 = 20.5.$$

In other words the amount of O_2 accounted for by the gas analyses is less than that which was introduced in the air according to the N_2 as obtained by difference. The following tabulation gives the results for other tests obtained in a similar manner.

Kind of coke	O_2 introduced with the N_2	O_2 accounted for as CO, CO_2 and O_2	Difference
Clairton, natural size.	20.5	16.6	3.9
Clairton, natural size.	19.5	17.4	2.1
Clairton, through 1½-in. screen	20.0	14.4	5.6
Clairton, through 1½-in. screen	19.6	14.4	5.2
Clairton, through 1-in. screen	20.3	12.8	7.5
Clairton Domestic coke	19.0	17.0	2.0
Clairton Domestic coke	18.7	15.8	2.9

The air used in the tests by Lose was held constant. However, the amount of coke consumed increased in general as the size of the same coke was decreased. Although there are some apparent inconsistencies between the reported gas analyses and the coke consumed, the percentage of CO in the exit gases increased in general as the size of the same coke was decreased. It is difficult to see how less coke was burned in the check test on Clairton coke, natural size, when the CO in the gas was 18.8 per cent as compared to 12.4 per cent in the first test. The relation between size and CO_2 in the exit gases is due to the fact that the coke bed made up of the smaller pieces offered a better oportunity for contact between the O_2 of the air, and CO_2 in the gas stream, and the solid pieces of coke. As the CO in the exit gas from a fuel bed approaches 34.34 per cent, the maximum amount obtainable when pure carbon is burned with dry air, more carbon will be burned per unit of air supplied for the obvious reason that twice as much C is united with a unit of O_2 in CO, as compared to a unit of O_2 in CO_2.

The various tests which have been proposed for measuring the combustibility of coke do no doubt provide a means of determining at least qualitatively the variations in combustibility under laboratory conditions. However, the results of tests made in fuel beds which do not provide opportunity for complete conversion of the O_2 of the air and CO_2 to CO are apt to be misleading when applied to the blast furnace. For example, Lose concludes from the tests made in a hand-fired furnace, 46 in. high, that small sizes of Clairton coke will burn at a faster rate in the blast furnace than will larger pieces of the same coke.

Bureau of Mines Investigations on Coke in the Blast Furnace

The overall rate of carbon gasified at the tuyeres of a blast furnace is determined by the rate at which air is supplied and is independent of coke size, except as the size of the fuel may affect the rate of oxygen delivered to the furnace. Perrott and Kinney[14] have confirmed the less comprehensive experiments of earlier investigators, which indicated that combustion of coke at the tuyeres of a blast furnace is completed within 30 to 40 in. beyond the nose of the tuyeres. In other words, all of the oxygen of the air and the CO_2 gas produced near the tuyeres have been converted into CO, and no further combustion can take place by the blast. Fig. 1 shows the average gas analyses from the tuyere zones of 13 furnaces.

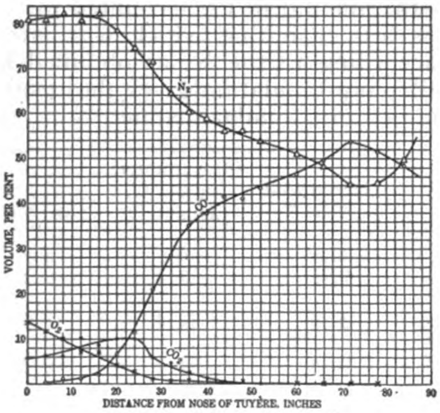

Fig. 1

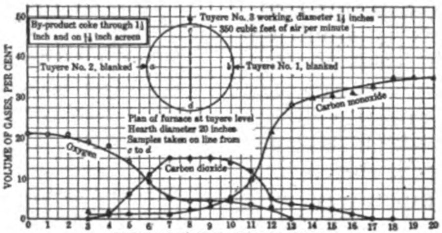

Fig. 2

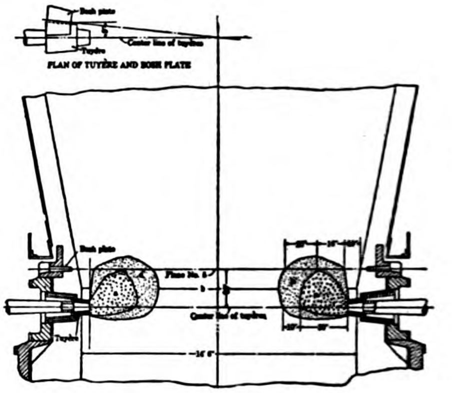

Fig. 3

Lose referred to the tests made by the Bureau of Mines as follows:

> "The conclusion of the investigators as a result of these tests was that complete combustion of the coke to CO is accomplished at a fixed distance from the nose of the tuyere (about 40 in.) in all cases, regardless of coke size, coke quality, blast temperature or velocity of wind through the tuyere."

The conclusions of the Bureau of Mines investigators are based upon the analyses of samples of gas withdrawn from the tuyere zone of 13 furnaces, using coke made in Semet-Solvay by-product ovens, Koppers by-product ovens, bee-hive ovens and Roberts ovens; the coking time varied from 16 to 72 hours, porosity from 44 to 53, and true specific gravity from 1.84 to 2.13 shatter tests, from 42 to 70. Notwithstanding the variations in the coke used in these furnaces, combustion was practically completed within 32 to 40 in. from the nose of the tuyere. Combustion is not completed at a fixed distance regardless of coke size, coke quality, blast temperature, or velocity of wind through the tuyeres, but variations in the size or extent of the combustion zones in the 13 furnaces investigated were a matter of inches and too small to be related to any properties of the coke or other operating details. From Lose's statement regarding the work of the Bureau of Mines and also from the fact that he applies the results of his tests in hand-fired furnaces, in which combustion to CO was not complete, to the blast furnace, it seems evident that he still holds to the belief formerly held by many operators that combustion in the tuyere zone of the blast furnace is not confined to a rather restricted volume, but extends to some indetermined height in the furnace. The results reported by Lose, which show that combustion was not complete in a hand-fired furnace, 46 in. high, cannot be accepted as proof that combustion is not completed within about 40 in. of the tuyere nose in a blast furnace. The lack of preheated air in the tests with the hand-fired furnace, the lower temperature in the fuel bed, and the absence of the slagging-action present at the tuyeres of a blast furnace make the conditions of his experiment widely different from those at the tuyeres of a blast furnace.

Fig. 2 shows the results of gas analyses from the tuyere zone of a 6-ton experimental furnace which the Bureau of Mines has operated. The coke used in this test was sized to pass through 1½-in. screen and on 11/16 in. It approximated the smaller sizes of Clairton coke used by Lose. The composition of the gases in the two cases differs widely. In the hand-fired furnace the gas, issuing from a fuel bed 46 in. high, contained a maximum of 27.6 per cent CO and 2.0 per cent CO_2. Under blast-furnace conditions the oxygen disappeared in about 13 in. and the CO_2 in 17 to 18 in. In other words, combustion was complete in 18 in. under actual furnace conditions, whereas in the hand-fired furnace it had not been completed in 46 in.

Height of Combustion Zone above Tuyeres

Perhaps some doubt exists as to the extent of the combustion zone in a vertical plane above the tuyeres. While the number of samples of gas removed from positions above the tuyere plane are small in comparison to the number removed in a horizontal position through the tuyeres, there is no reason to believe that the combustion zone extends a greater distance in a vertical direction than in a horizontal direction. In 1924, Kinney[15] removed samples of gas across a plane 27 inches above the tuyeres of a 300-ton furnace and found that the maximum percentage of CO_2 across this plane was about equal to the percentage of CO_2

found in a horizontal direction from the tuyere nose. Data obtained by Van Vloten and summarized by Perrott and Kinney[16] also show about the same penetration of CO_2 in a vertical direction as exists in a horizontal direction (see Fig. 3).

Basis of the Various Conceptions of Combustibility

After considering the various definitions which have been given for the combustibility of coke and the various methods proposed to measure differences in combustibility, the lack of a common understanding of what really constitutes differences in combustibility is very evident. Several ideas seem to be the basis for the various conceptions of this property of fuel. Most of the definitions express the idea that a highly combustible coke is one that will burn rapidly at the tuyeres of a blast furnace. Brassert and Howland refer to the concentration of heat resulting from a fast-burning coke, which embodies the idea of changes in size of the combustion zone with changes in combustibility. Korevaar also refers to the size of the combustion zone. Sweetser, Read, and Lose refer to rates of combustion, and do not embody in their definition the changes in volume of the combustion zone. Koppers and Fischer emphasize reactivity of coke with CO_2. This property of coke is usually considered in connection with the behavior of coke in the upper portion of the blast furnace, where the temperatures are much lower than the temperatures in the tuyere zone. A coke with high reactivity toward CO_2 would be oxidized to a greater extent above the tuyeres and would require less air per pound of coke. The general conception seems to restrict combustibility to the conditions existing at the tuyeres.

Generally speaking, the two ideas which seem to be embodied in the various conceptions of combustibility are, first, the idea of rate and, second, the idea of a change in volume of the combustion zone. As previously pointed out, the rate of burning of coke at the tuyeres of a blast furnace is directly proportional to the air supply, because the gases leaving the combustion zone are largely CO and N_2 and a fixed relation exists between the amount of O_2 combined with a given weight of carbon. If the rate of air supply is doubled, the rate of burning is doubled. Any definition which refers to a rate, alone, is incomplete because the combustibility of the same coke can be doubled by doubling the air supply. If constant conditions of blast temperature and volume are assumed, such as proposed by Sweetser and Read, then the rate of carbon gasification will also remain constant. In order to relate combustibility of coke with some physical or chemical properties of the coke, rather than define it as a mere rate of combustion dependent upon the air supply, it is necessary to inject a space rate concept into a definition of combustibility. Perrott and Kinney have done this in their definition of combustibility which follows: "Combustibility of coke from the standpoint of its use in the blast furnace is inversely proportional to the mean rate of gasification per unit volume of the combustion zone, assuming that other factors remain constant."

As Brassert pointed out, each molecule of oxygen will find an atom of carbon within a shorter distance if the coke is more combustible, as a result the combustion zone will be smaller for coke having greater combustibility. With a fixed rate of air supply the overall rate of combustion expressed in pounds of fixed carbon per unit of time also becomes fixed. However, if the size of the combustion zone changes, the space rate of combustion will also change accordingly. If the volume of the combustion zone is halved, by reason of a change in combustibility, the space rate of combustion will be doubled.

Penetration and Combustibility of Coke

If combustibility of coke is conceived to refer to those properties which determine the space required for its combustion at the tuyeres of a blast furnace, it is believed that this term will be more useful in interpreting furnace practice. Furnace operators have observed in practice that changes can be made in the general operation of a blast furnace by using tuyeres of different cross-section and length. Changes in the velocity of the blast through the tuyeres and the length of the tuyeres alter the working of the furnace with respect to the bosh and hearth walls, and also affect the mechanical agitation of the coke by the blast. The latter effect will be discussed later. Changes in the size of the coke lumps reaching the hearth have much the same effect as changes in the size of tuyeres. If the coke reaches the hearth in small pieces, the zones of combustion in front of the tuyeres will be smaller; the position of maximum CO_2 will be nearer the walls and the general results will be much the same as those produced by lack of penetration. As the combustion zone is drawn in toward the furnace walls, more gas is deflected along the bosh walls.

The writer [17] has pointed out that the position in which the coke is burned at the tuyeres has an effect on the movement of stock in the blast furnace. A highly combustible coke or one which will be burned in a smaller space, nearer the tuyeres, will cause greater movement along the walls than a less combustible coke which will be consumed at greater distances from the wall. The height to which the effect of localized combustion is transmitted in the shaft is governed by furnace lines.

It has been suggested that the mechanical agitation of the coke by the blast may extend beyond the zone in which the coke is consumed and there cause a shrinking of the coke column by reason of the fact that pieces from beyond the zone of combustion are shifted into the region of burning. The gas samples taken by Perrott and Kinney and their observations while exploring the hearth with water-cooled gas-sampling tubes throw light on this point. Samples removed along a horizontal plane extending from the tuyere nose to the center of the furnace disclosed a progressive increase in CO and a similar decrease in N_2. If the mechanical stirring of the blast extended beyond the combustion zone, one would expect to find only a small difference in the gas composition in the combustion zone and the region surrounding it. The rapid increase in CO indicates a restricted gas flow in the center of the furnace at the tuyere levels. By the time the gas reaches the top of the bosh there has been an equalization in flow. The relative resistance of the stock column controls the gas flow in the upper part of the furnace.

In regard to penetrating the stock column with a water-cooled sampling tube, having a blunt end and an outside diameter of 2 in., Perrott and Kinney[18] made the following statement:

> "In the average southern furnace and in Pennsylvania 1, the pipe could be pushed in easily for 24 in. from the tuyeres. At Pennsylvania 2, it was possible to push in the pipe to 32 to 36 in., and at

> Pennsylvania 3 and 4 and Illinois about 32 in. At the point at which the pipe must be driven in by the blows of a dolly, it is evidently in contact with a fairly solid bed of coke, which is not being consumed rapidly."

Size of Combustion Zone and Size of Coke

In the experiments performed by the Bureau of Mines, the size of the coke lumps has been found to exert a greater effect upon the size of the combustion zone than the inherent properties of the individual pieces. Sizing of coke affords a means of changing the size of the combustion zone. The ability of the coke lumps to retain their size and shape until the combustion zone is reached depends upon the inherent properties of the individual lumps. The strength of the coke therefore has a bearing upon the extent of the combustion zone. Lose has suggested that:

> "Where blast pressures are low, the movement of the furnace is smooth, and fluid acid slags can be carried; crushing the coke to a size consistent with the maintenance of smooth regular operation possibly would result in a betterment of coke practice with a consequent increase in production."

Crushing the same blast-furnace coke will not increase its rate of burning at the tuyeres because this rate is fixed by the weight of oxygen delivered to the furnace and the fixed carbon in the coke. It will, however, increase the space rate of combustion inasmuch as the same quantity of coke will be burned in a smaller volume. However, it appears that the combustion of run-of-the-oven coke, at the tuyeres of a blast furnace, is concentrated into a space so small as to exceed the fondest hope of those advocating concentration of hearth heat. With present methods of charging, American blast furnaces have a relative dense periphery and an open center, which deflect greater amounts of gas to the center. Localized combustion causes faster movement of stock at the periphery of the furnace. Small coke would accentuate this effect and tend to reduce contact between gas and solid in the shaft, a matter of vital importance. Other things being the same, large pieces are preferred to small ones.

Uniformity of coke size would produce greater uniformity of condition in the combustion zone. Although little is known of the mechanical action in the tuyeres in relation to coke properties, the size of the zones into which the coke is moving and the stirring of the coke by the blast no doubt affect furnace practice. Uniformity of coke size would tend toward uniform conditions in the combustion zone.

Experimental data are not complete enough to determine the exact shape of the combustion zone, but assuming that it is spherical, the volume of the zone around each tuyere is about 20 cu. ft. (see Fig. 3). If 4,000 cu. ft. of air are entering each tuyere per minute and the fixed carbon in the coke is 86 per cent, and its density 1.0, about 2 cu. ft. of coke will be burned per minute. In other words, the coke in the combustion zone would be replaced every 10 minutes. Under the foregoing conditions the diameter of a 5-in. piece of coke would recede at a rate of approximately ½ in. per minute. This illustrates the fact that there is intense combustion at the tuyeres of a blast furnace. Although modern furnaces have a large amount of reserve heat, interference from any cause, such as cold material from the walls above the tuyeres or sculling of material on the walls below the tuyeres, upsets the intense combustion in front of the tuyeres and starts a downward trend in temperature.

Although the blast may be heated to temperatures ranging from 1,100 to 1,400 deg. F., the blast has a chilling effect upon the lumps of coke directly in front of the tuyeres. Ash forms as the surface recedes and, although some of the ash may be blown away or fuse and part of it drop off the coke lumps, the most advantageous condition occurs when the coke directly in front of the tuyeres remains there for a short time only, being shifted at short intervals into a zone of higher temperature and more active slagging action. Under these conditions a clean surface is presented for combustion. It appears that the stirring of the coke by the blast is important in blast furnace practice; the action is a mechanical one and there seems to be little information which will relate it to coke properties.

Carbon Gasified above the Tuyeres

In the preceding discussion, rates of combustion have referred to rates of combustion at the tuyeres. However, a portion of the coke is gasified outside the combustion zones at the tuyeres by contact with CO_2 derived from the reduction of the ore or calcination of the stone. The extent to which CO_2 attacks the coke has generally been considered to be a function of coke reactivity. Table 2, compiled from various sources, shows the variation in carbon reaching the tuyeres of 55 American furnaces, 10 British furnaces, and several German furnaces.

The carbon consumed per ton of pig iron varies from 1,403 to 2,700 lbs. in the American furnaces and from 1,319 to 2,676 lbs. in the 10 British furnaces. An average of 384 lbs. of carbon per ton of metal was gasified outside the combustion zones at the tuyeres in the American furnaces. In general, solution loss or premature combustion has been referred to as taking place above the tuyere level. The work of Perrott and Kinney has shown, however, that there is considerable gasification of carbon by oxygen of the charge in the center of the furnace at the level of the tuyeres. Evans[19] found in investigating a large number of British furnaces that an average of 300 lbs. of carbon was gasified above the tuyeres. There does not appear to be any marked relation between fuel consumption and the carbon gasified above the tuyeres in the furnace listed in Table 2. The general tendency is for less carbon to reach the tuyeres in the furnaces with lowest fuel consumption. This is borne out by a comparison of the British and American furnaces and is due primarily to the higher concentrations of CO_2 encountered in the low coke furnaces. In general, other things being equal, fast driving will, because of the shorter time that the stock is in the furnace, result in the greater gasification of carbon above the tuyeres. Iron ores, which are difficult to reduce, or large pieces of ore of normal reducibility, will also increase the gasification of carbon above the tuyeres. Limestone which calcines slowly is another factor which increases gasification above the tuyeres. Considering the wide range of operating conditions covered in this series of furnaces, the variation in the carbon gasified at the tuyeres is surprisingly small. In this connection Evans has made the following statement:[20]

> "If the mathematical methods that are available are sound, reactivity of coke seems to play very little part in determining the total amount of solution or direct reduction in the furnace, and the ap-

proximate constancy of this figure seems to point to the reaction being one that is kept balanced by thermal conditions."

Fieldner and Davis[21] have investigated the reactivities of five gas-works cokes, a low-temperature coke and two bee-hive cokes, toward air, CO_2 and water vapor. With the exception of the low-temperature coke and one of the gas-house cokes, the others did not vary greatly in reactivity. In general these investigators found that the order of reactivity of these cokes in the three media was the same.

TABLE 2.—AMOUNT OF CARBON GASIFIED AT THE TUYERES OF 71 BLAST FURNACES.

Furnace.	Pounds coke per ton of metal.	Pounds carbon per ton of metal.	Pounds carbon gasified at tuyeres.	Pounds carbon gasified above tuyeres.	Per cent. carbon charged as coke gasified at tuyeres.	Furnace.	Pounds coke per ton of metal.	Pounds carbon per ton of metal	Pounds carbon gasified at tuyeres.	Pounds carbon gasified above tuyeres.	Per cent. carbon charged as coke, gasified at tuyeres.
H. 1[a]	2,615	2,254	1,868	386	82.8	H. 14	1,742	1,474	1,133	341	76.9
2	2,551	2,153	1,751	402	81.4	15	1,716	1,494	1,194	300	80.0
3	2,472	2,128	1,728	400	81.2	16	1,715	1,451	1,114	337	76.7
4	2,247	1,957	1,605	352	82.0	17	1,702	1,490	1,130	361	75.9
5	2,198	1,908	1,494	414	78.7	18	1,699	1,479	1,155	324	78.2
6	2,123	1,875	1,498	377	79.8	19	1,673	1,482	1,182	300	79.9
7	2,115	1,782	1,427	355	80.1	20	1,658	1,464	1,182	282	80.8
8	1,996	1,722	1,303	419	75.6	21	1,636	1,463	1,124	339	76.8
9	1,936	1,659	1,305	354	78.8	22	1,635	1,447	1,124	323	77.7
10	1,905	1,690	1,252	438	74.1	23	1,624	1,417	1,118	299	79.0
11	1,901	1,625	1,274	351	78.4	24	1,623	1,454	1,090	364	75.0
12	1,863	1,614	1,230	384	76.2	25	1,589	1,403	1,100	303	75.8
13	1,780	1,511	1,124	387	74.4	26	1,584	1,413	1,057	356	74.8
P&K. Ala. 1[b]	3,160	2,737	2,381	356	87.0	P&K. Pa. 1	2,800	2,372	1,779	593	75.0
2	2,800	2,307	1,661	646	72.0	2	1,700	1,459	1,080	379	74.0
3	1,900	1,658	1,293	365	78.0	3	2,465	2,039	1,672	367	82.0
4	2,645	2,306	1,776	530	77.0	Ill. 1	1,770	1,457	1,064	393	73.0
5	2,765	2,400	1,848	552	77.0						
J. 1[c]	1,586	1,480	1,120	360	75.7	J. 11	2,085	1,780	1,435	345	80.6
2	1,907	1,645	1,249	396	75.9	12	1,720	1,518	1,154	364	76.0
3	1,892	1,631	1,306	325	80.1	13	1,950	1,720	1,304	416	75.8
4	1,935	1,680	1,302	378	77.5	14	1,845	1,628	1,257	371	77.2
5	1,958	1,663	1,187	476	71.4	15	2,120	1,855	1,514	341	81.6
6	2,070	1,765	1,493	272	84.6	16	2,450	2,090	1,728	362	82.7
7	2,040	1,743	1,241	502	71.2	17	2,158	1,832	1,418	414	77.4
8	2,315	1,955	1,537	418	78.6	18	2,213	1,879	1,432	447	76.2
9	1,704	1,502	1,125	377	74.9	19	2,232	1,965	1,493	472	76.0
10	1,932	1,720	1,472	248	85.6	20	2,354	2,145	1,742	403	81.2
E. 1[d]	2,037	1,819	1,523	296	83.7	E. 6	2,478	2,007	1,760	247	87.7
2	2,608	2,152	1,841	311	85.5	7	2,685	2,258	1,830	428	81.0
3	2,570	2,261	1,815	446	80.3	8	2,444	2,072	1,647	425	79.5
4	2,856	2,146	1,815	331	84.6	9	2,688	2,286	1,880	400	82.2
5	3,463	2,676	2,359	317	88.2	10[e]	1,685	1,391	1,080	311	77.7
G. 2[f]	2,564	1,960[g]	1,541	419	78.6	L. 1[f]	2,464	2,277	1,727	550	75.8
3	2,078	1,675	1,317	358	78.6	[h]2	1,658	1,456	1,111	345	76.3
4	2,828	2,148	1,698	450	79.1	R. [h]1[f]	1,528	1,244	966	278	77.7

[a] Furnaces listed by Howland. (See footnote 3.)
[b] Furnaces listed by Perrott and Kinney. (See footnote 15, p. 558.)
[c] Furnaces listed by Joseph. (Unpublished report.)
[d] Furnaces listed by Evans. (See footnote 20.)
[e] White basic iron.
[f] Furnaces listed by Gilhausen, Ledebur, and Richards. (See footnote 6, p. 381.)
[g] Average value. (See footnote 6.)
[h] Charcoal furnaces.

Carbon dioxide, liberated in the furnace at positions where the temperature is several hundred degrees above that required for reaction between C and CO_2, will be reduced to CO by coke having a small reactivity. In other words, the amount of solution loss depends not alone upon the coke quality, but also upon the extent to which the ore is reduced and the limestone calcined before reaching a position in the furnace where the temperature is such that the reaction rate between CO_2 and C is very rapid. Gases removed from the center of the hearth at the tuyere level show that carbon is being gasified at this leved by oxygen from the charge. Extreme types of coke show differences in reactivity with CO_2, under laboratory conditions (950 to 1,000 deg. C.) Charcoal is generally considered to be very reactive. The small amount of air used per pound of charcoal is due to the fact that it normally contains less fixed carbon than coke and also to greater gasification of carbon above the tuyeres. In general, soft under-coked fuels, carbonized at low temperatures, are more reactive. However, soft cokes, while they may approach the reactivity of charcoal towards CO_2, are not as free from ash and sulphur and do not therefore permit extremely acid slags of low critical temperatures, all of which tend toward low fuel consumption. If charcoal were no more reactive to CO_2 than coke, it would no doubt be possible to obtain still lower fuel consumption in charcoal furnaces.

Increased rates of driving often observed in practice are believed to be due in a large measure to some condition which changes the extent of preparation of materials in the shaft rather than to changes in the coke. If, for example, the distribution of the gas is upset, minimizing contact between gas and solid in some parts of the furnace, material which has not been properly prepared will reach a level in the furnace at which coke will be acted on by CO_2. Stream lines of stock descent, resulting from localized combustion at the tuyeres, will produce faster settling of the stock in some parts of the furnace, thus shortening the period for reduction of the ore and calcination of the limestone at lower temperatures.

Fast-Burning Coke

The overall rate of fuel consumption in a blast furnace expressed in pounds of carbon consumed in the furnace per unit of time depends upon (1) the rate of air supply by weight, which fixes the rate of combustion at the tuyeres, and (2) the amount of carbon gasified above the tuyeres. Other things being equal, more reactive cokes will be consumed more rapidly than will less reactive cokes. Although there may be some advantages from the smaller volume of gases passing through the furnace when more reactive cokes are used, the writer believes that in general more efficient operation will be obtained the more closely Gruners' ideal is approached. The rate of blowing is the primary means of controlling the rate of combustion. Recent rapid strides toward increased production per furnace have been due to larger furnaces and in some cases to somewhat faster rates of blowing per cu. ft. of working volume. If rates of blowing are expressed in terms of cu. ft. of air per sq. ft. of hearth area per minute rather than in terms of furnace volume, modern large-hearth furnaces appear to be slowly blown, because the hearth area has been increased more than the working volume. A change from an 11-ft. hearth to a 22-ft. hearth represents a four-fold increase in hearth area, while the change in volume has been more nearly a two-fold increase.

McKee[22] has pointed out that the stock-line area has not been increased nearly as much as the wind volume. As a result of the high gas velocities in the top section of the furnace, the production of flue dust and irregular movement of the furnace, rather than the ability of the coke to burn, are the factors limiting the amount of coke which can be consumed in modern furnaces using fine Lake ores. There is considerable variation from plant to plant in rates of blowing. The cu. ft. of wind per cu. ft. of working volume may vary from 1.75 to 2.5, depending upon plant practice. In general, strong cokes of low density permit faster blowing by reason of producing a more open charge.

If coke is charged by volume, variations in coke density will change the rate of driving, if judged entirely by the number of rounds charged and no check is made against coke weight. The writer[23] has pointed out that:

> "If the fixed carbon remains constant, each increase in density of 0.1 will require 200 cu. ft. of additional air to burn a cu. ft. of coke."

Therefore, if more air is not supplied when denser coke reaches the tuyeres, the furnace will take less rounds per day. Because of variations in rates of blowing and in the apparent density of coke, the volume of coke consumed per minute may vary from furnace to furnace over a range of almost two to one.

Size and Strength of Coke and Resistance of the Charge to Flow of Gas

The use of Mesabi iron ore has necessitated several changes in practice. Vreeland[24] has mentioned the increase in hearth diameter and bosh angle, and the method of placing the materials on the large bell. One item of particular interest he referred to was the necessity of using a large bell to keep the furnace moving. The effect of the large bell without the use of some device under it, such as the Killeen distributor, the MacDonald ring, or the Slick distributor, was to produce a decided difference in the porosity at the periphery and center of the furnace. It would appear in view of the standard practice of 2-ft. bell clearance, which produces the condition just referred to, that an open center is necessary as a relief valve to allow the escape of sufficient gas to permit regular movement of the stock. A dense periphery is also desired to diminish lining renewals.

The preceding paragraph illustrates the marked effect which the increased use of Mesabi ore has had upon the resistance of the charge to gas flow. Although the fine ore offers a much greater potential surface for contact with the gas stream, the problem of providing an oportunity for heat transfer and reduction through contact between gas and solid is one of outstanding importance. Aside from furnishing heat and CO, the coke has another very important function of decreasing the resistance of the charge to gas flow. In general, coke will fulfill this object more satisfactorily if the pieces are large and retain their size until reaching the tuyeres. A light porous coke, because of the greater volume it occupies in the furnace, tends to decrease the overall resistance of the charge.

In order to obtain fundamental information which will apply to the problem of forcing large volumes of gas countercurrent to a column of descending solids composed of various sizes of particles, the Bureau of Mines at its North-Central Experiment Station has undertaken a series of laboratory experiments to determine the relative resistance which beds of irregular solids offer to the flow of gases. The effect of arranging the various components, such as ore, coke, and limestone, in separate layers will be investigated.

Summary and Conclusions

1—It is believed that failure to define the properties of coke clearly is partly responsible for retarding progress in correlating coke porperties and furnace practice. Combustibility of coke has been widely discussed in the technical press and many views have been expressed as to what constitutes differences in combustibility and how such differences may be measured.

2—If combustibility, a property of the fuel, is distinguished from rate of combustion, a factor controlled by rate of air supply, the term is of value in relating coke quality and furnace practice. Highly combustible coke will not burn faster before the tuyers than less combustible coke, but it will burn in a smaller volume. The size of the combustion zone, controlled largely by the size of the coke, affects the working of the furnace with respect to the furnace walls. More combustible coke shifts the position of maximum CO_2 nearer the walls and results in concentration of heat toward the periphery of the furnace at the tuyere level. The size of the combustion zone affects the descent of the stock in the furnace. The predominating tendency is for the material to feed directly into the zone where the coke is shrinking as a result of combustion. Mechanical agitation by the blast is important, but there are no data to relate it to the various properties of coke. Gas samples taken from the tuyere level and observations by Perrott and Kinney when forcing a water-cooled sampling tube into the center of the furnace indicate that the mechanical stirring does not extend beyond the zone of active combustion. As the combustion zone becomes smaller it would appear more difficult for the coke to move into the zone of combustion.

3—The conditions in the fuel bed of hand-fired laboratory furnaces, designed to determine differences in combustibility, are different from those existing at the tuyeres of a blast furnace; therefore the distance required to burn completely to CO in a hand-fired furnace cannot be taken as a measure of the distance required to accomplish this result in the blast furnace. The distance from the grate bars required to burn completely to CO or the approach to saturation of the gas with carbon, as shown by the gas composition at any point in the fuel bed, can be used to measure relative combustibilities, under properly controlled conditions.

4—Under blast furnace conditions a fixed amount of air will consume a definite quantity of carbon in front of the tuyeres. Variations in the carbon gasified by contact with CO_2 outside the tuyere zone will affect the number of charges per day, when the wind remains constant. Data representing a wide range in operating conditions and various types of coke show that the average amount of carbon gasified above the tuyeres is surprisingly constant. Extreme cokes show a difference in reactivity with CO_2 at temperatures of 950 to 1,000 deg. C., but the difference for two cokes of about the same type is small. Conditions which control calcination of limestone and reduction of the ore before reaching temperatures at which CO_2 will react rapidly with coke or even small reactivity are believed to fluctuate more than coke made under modern oven practice. Progress toward larger production per furnace has been attained by increasing bosh and hearth diameters and in some cases by blowing more wind per unit volume of the furnace, but not per sq. ft. of hearth area. Hearth areas have increased about 4 to 1 since the days of 11-ft. hearths, whereas the volume has more nearly doubled.

5—The use of Mesabi ore presented a new problem in blast furnace practice, namely, that of moving a large quantity of fine ore under the force of gravity, countercurrent to a large volume of gas. Present practice seems to have settled upon a big bell clearance which produces a dense periphery and a porous center, the latter acting as a relief valve for sufficient gas to permit regular stock movement. The dense periphery was also adopted to decrease lining renewals.

6—One important function of coke is to decrease the resistance of the charge to gas flow. This function, which is more important with the use of fine ore, is more satisfactorily performed by large pieces of coke of low density which will retain their size until reaching the tuyeres.

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7—It appears that the physical properties of coke bear an important relation to the physical and mechanical problems presented by the blast-furnace process.

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Physical Chemistry of Steel to be Studied

A five year's program of scientific studies in the physical chemistry of steel making to be carried out by the Carnegie Institute of Technology, the U. S. Bureau of Mines, and an advisory board of Pittsburgh steel executives and metallurgists has been launched according to an announcement. Twenty-six steel companies located east of the Mississippi River will cooperate in the work.

Pledges of support in undertaking the research program were given by 65 representatives of the 26 cooperating steel companies at a dinner given for them and members of the advisory board by President Thomas S. Baker at the Carnegie Institute of Technology on October 19. The dinner meeting was preceded by inspection in the afternoon of the metallurgical laboratories of the Bureau of Mines and the laboratories of the Department of Metallurgy and the Bureau of Metallurgical Research at Carnegie Institute of Technology.

Speakers at the meeting included Dr. Thomas S. Baker, president of Carnegie Institute of Technology; Dr. John Johnston, director of the Department of Research and Technology, United States Steel Corporation; Scott Turner, director, U. S. Bureau of Mines, and Dr. C. H. Herty, Jr., head of the Ferrous Metallurgical Section of the U. S. Bureau of Mines, who gave a progress report on the co-operative research.

Guests of President Baker and the advisory board, included the following:

Zay Jeffries, Aluminum Company of America; W. E. Caugherty, Allegheny Steel Company; M. W. von Bernewitz, American Institute of Mining and Metallurgical Engineers; W. J. Beck and Hunter Nead, American Rolling Mill Company; H. R. Belding, American Sheet & Tin Plate Company; W. C. Hamilton and C. E. Sims, American Steel Foundries; F. C. Elder, American Steel & Wire Company; H. T. Morris, Bethlehem Steel Company; Charles Longenecker, Blast Furnace and Steel Plant; Felix Kromp, Braeburn Alloy Steel Company; J. E. Fletcher, British Iron and Steel Institute; Professor James Aston, Dr. F. M. Walters, Jr.; Dr. J. B. Friauf and Dr. V. N. Krivobok, Carnegie Institute of Technology; Dr. J. S. Unger and J. T. MacLeod, Carnegie Steel Company; J. T. Morris, Central Alloy Steel Corporation; Congressman H. Clyde Kelly; R. E. Sherlock, Donner Steel Company; M. A. Smith, Edgewater Steel Company.

J. A. Succop and R. B. Heppenstall, Heppenstall Forge & Knife Company; L. S. Marsh, Inland Steel Company; E. E. Thum, The Iron Age; H. A. Smalley, Jessop Steel Company; H. W. Graham, Jones & Laughlin Steel Corporation; L. W. Mesta and C. I. Niedringhaus, Mesta Machine Company; Ivan B. McCorkle, National Tube Company; R. M. Keeneh, F. F. McIntosh and C. I. Pringle, Pittsburgh Crucible Steel Company; A. R. Maxwell, Harry Watt and Ray Simmons, Pittsburgh Steel Company; H. P. Grafton, Trumbull Steel Company; A. L. Field, Union Carbide Company; A. C. Fieldner, G. St. J. Perrott, B. M. Larsen and J. M. Gaines, Jr., United States Bureau of Mines; George W. Vreeland and John D. Gold, Weirton Steel Company; W. J. Merten, Westinghouse Electric & Mfg. Company; G. A. Reinhardt, Youngstown Sheet & Tube Company.

Members of the metallurgical advisory board at the meeting were:

T. D. Lynch, Westinghouse Electric & Mfg. Company, chairman; Earl Blough, Aluminum Company of America, vice chairman; Edward Steidle, Carnegie Institute of Technology, secretary; R. E. Zimmerman, American Sheet & Tin Plate Company; A. N. Diehl and C. F. W. Rys, Carnegie Steel Company; R. H. Davis, Crucible Steel Company of America; F. B. Bell, Edgewater Steel Company; Kenneth Seaver, Harbinson-Walker Refractories Company; T. M. Girdler, Jones and Laughlin Steel Corporation; F. W. Speller, National Tube Company; W. E. Moore, Pittsburgh Electric Furnace Corporation; S. G. Stafford, Vulcan Crucible Steel Company; E. T. McCleary, Youngstown Sheet and Tube Company.

British Rolling-Mill Practice Reviewed*

A British Engineer Points to Several Details, in the Design of Rolling Mills, Which Have Effected Considerable Improvement in Operation

By F. H. R.

IT has been often assumed by our critics at home that we have no engineering ability in Britain equal to designing a modern rolling mill that can compare with either American or German practice. This belief is fostered by astute advertising and publicity, but in fairness to ourselves we should be ready to support home products, and this article is intended to describe briefly some features of rolling-mill design in which we are at least equal to the foreigner.

Leaving out of consideration the Ilgner reversing set, or equivalent electrical gear for a three-high mill, the first consideration is in regard to the coupling which connects the motor or flywheel shaft to the mill pinions. The design used in all modern American mills and German mills is called the "Ortmann" coupling with machine cut teeth, and a careful examination of the lower view in Fig. 1 will show that it does not, and cannot, drive along the full face, because of machining clearances. The result is that it drives off the toe of one tooth and the heel of the other, and the stress induced in the driving sleeve is not pure torsion; in addition, it permits of very little out-of-alignment and no adjustment.

We may now take the latest design of British mill couplings, which is in reality a large and special coupling box of the universal design which is shown in the upper view in Fig. 1. In this case the full bearing surfaces of the machined phosphor-bronze driving blocks are available, since there is no possibility of distorting the line of drive. There are two blocks on the end of the forged-steel driving crabs, giving a perfect couple and ensuring pure torsion on the sleeve, which is sometimes made in halves with solid registers, so that it can be taken apart at any time without dismantling the pinion housing. Should there be wear on the faces of the blocks, these can be readily adjusted, but the wear is very doubtful, as one such drive has been in operation 10 years without any need to take up wear. There are many alternatives to the actual coupling shown, but all the best are modifications only of this type, and are not made abroad.

Another strong point is that it is really a universal coupling in that it can drive with full efficiency even if the shafts are not in alignment. This is by no means a negligible property, because it obviates the drawbacks of inaccurate setting-up or any settlement in the foundations after erection. Should either occur, this coupling will continue to drive, and as the whole coupling is made of cast or forged steel, with the exception of the phosphor-bronze driving blocks, it is practically indestructible. It may be stated that the other design has given trouble, and in at least one case broke down completely, causing an expensive shutdown of the mill plant.

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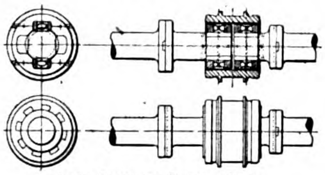
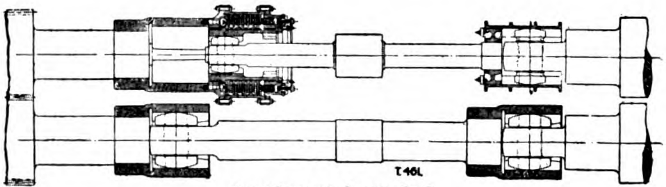
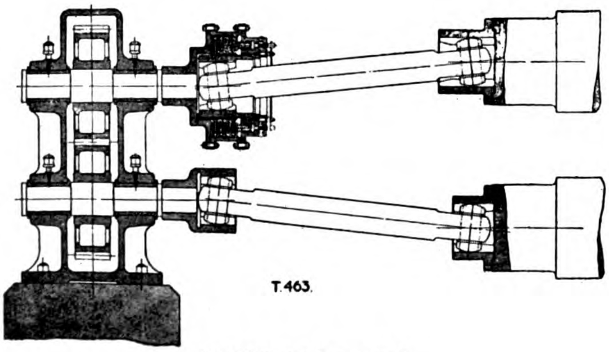
*Mechanical World.


British Rolling-mill Practice.—Fig. 1.



British Rolling-mill Practice.—Fig. 2.



British Rolling-mill Practice.—Fig. 3.

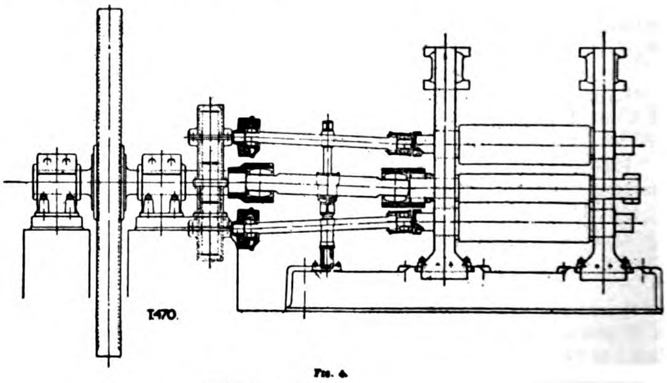
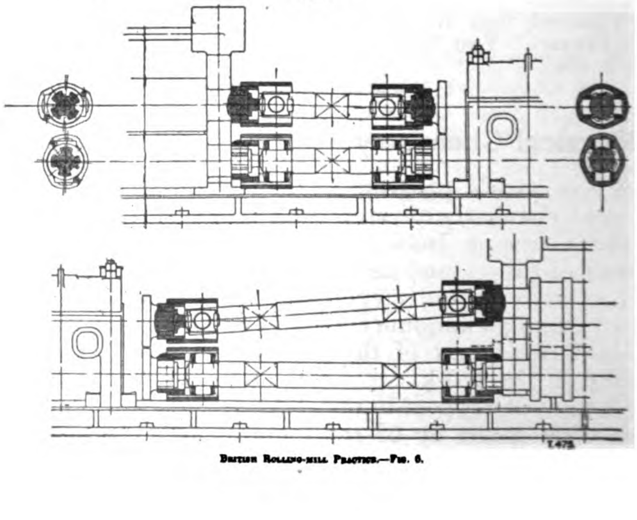


Fig. 4.



British Rolling-mill Practice.—Fig. 6.

Pinions

The next item is the pinion housing, about which little special claim can be made except in material and workmanship, but all pionion housings with one exception (and that British) have failed to provide adjustment in both the horizontal and vertical directions. In point of fact, the orthodox way has been adjustment in a vertical direction, in which the weight only is acting; whereas in the horizontal, where there is no adjustment, the working load of the mill pinions has to be met, and this load in the largest mills reaches 400 tons. In the design which allows for horizontal adjustment the bearings are made in four parts in the same manner as the main bearing of an engine crankshaft, and all adjustments can be made externally without any dismantling. No foreign-made or foreign-designed mill has this property.

These pinions and housings, with their attendant bedplates and oiling gear, run into thousands of pounds, and in addition it is necessary to keep a spare set of pinions and other details to effect repair when breakdowns take place. In one mill which has been running a little more than two years a complete set of pinions is now required.

It has now been proved by actual experience in England over a considerable period that pinions of a power required to transmit the full torque of the mill are not necessary. Fig. 2 shows the application of a slip-drive on the top roll of a roughing stand of a 42-in. plate mill, and the difference in size between the upper and the lower spindle indicates the reduced torque which is required to be transmitted when this gear is attached. This means that the pinions of the usual strength can be eliminated, and a pair of quite small gears inserted equal to about 15 per cent of the mill torque instead of 100 per cent.

In addition to reduced first cost and spares there will be no broken pinions, because when the shock of the entering piece which would have been transferred to the mill pinions occurs, the slipping surfaces come into operation and the shock does not reach the toothed gears. In addition, there is reduced power consumption.

This gear has also been attached to the finishing stand of a 42-in. plate mill (Fig. 3) with complete success, and by obviating the heavy shock when the plate enters or leaves the rolls, there is no danger of the breaking of rolls which is so common from this cause. This gear is so successful that a plate can enter and leave the rolls when running at 1,000 ft. per min., and the mill can roll plates down to a thickness of 1/8 in. with a length of 100 ft. This feature was in use in England several years before it was taken up in America; it is protected by patent in England.

One of the strong claims of the drive, no matter what type of mill, is that rolls of unequal diameter can be used constantly without causing any distortion to the plate or section, and any roller knows what an advantage this means.

In addition to the application to reversing rolling mills, it is applied to three-high mills as indicated in Fig. 4.

Spindles

It will be noticed that all the spindles on these devices are of the same design, which is, in addition to being a real universal spindle, absolutely indestructible, a property in great contrast to the spindles of the American mills in particular.

In Fig. 5 there is a reproduction of the bed-plates of the 42-in. plate mill referred to previously, erected in the works of Duncan Stewart & Company, Glasgow. Instead of the usual double-vee design favored by foreign engineers, these foundation girders are made similar to the bedplates used on reversing engines, and this allows correct alignment, after which the housings are secured into place by machine forged-steel wedges and held by 4-in. bolts, which makes the whole equipment very rigid. The bedplates shown are about 3 ft. 4 in. deep, and are securely tied together with cross-girders.

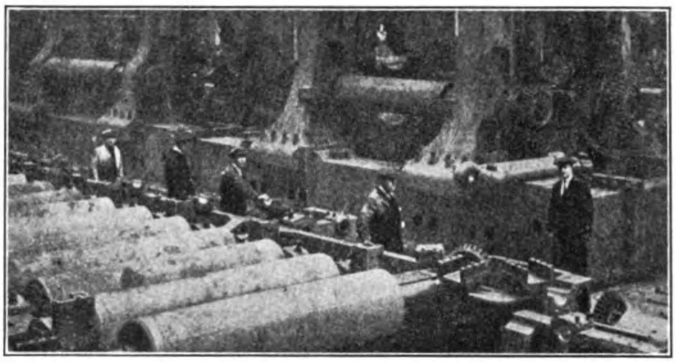


FIG. 5—Bed plate of 42-in. plate mill.

The last detail to be described is shown in Fig. 6, in a new type of patent universal spindle which can be applied to every roll on any steel mill. It can be adapted to all the rolls of an existing mill, as well as to a new mill; when applied to existing mills it has the additional advantage that it does not alter any existing method of roll changing or involve the expense of new rolls or new pinions. In addition, it eliminates entirely the old-fashioned fluted spindles and boxes, which have always been a source of great expense due to numerous breakages. The new spindles have machined surfaces, they are readily adjustable (and this prevents back-lash and its consequent shock), and the driving mechanism has the same universality as the spindles previously described.

The rolls can be changed without affecting the spindles, and the spindles also can be similarly changed without disturbing the rolls. There is a wedge device which eliminates any stretcher. In the upper view the spindles are applied to a plate mill, and in the lower view to a cogging stand, but they can be adopted to bar mills or stands with closed rolls.

Wickwire-Spencer in Receivers Hands

Edward C. Bowers, president of the Wickwire-Spencer Steel Corporation, and Charles L. Feldman, an attorney of Buffalo, are in charge of operations of the corporation as receivers under an order from Judge Hazel of the United States district court at Buffalo. No changes are contemplated in the operating program at least for some time.

The Wickwire-Spencer Steel Corporation was organized in November, 1919, the component companies being the Wickwire Steel Company, Buffalo; Spencer Iron Company, Spencer and Worcester, Mass.; Wright Iron Company, Worcester and Palmer Mass.; Morgan Spring Company, Worcester, Mass; National Manufacturing Company, Worcester, Mass., and Clinton Wire Cloth Company, Clinton, Mass.

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Properties of Metallurgical Coke

A Recital of the Properties and Characteristics Coke Should Possess in Order that It May Serve Most Efficiently as a Fuel in the Blast Furnace

By R. P. HUDSON*

THE original method of producing coke probably had its inception in charcoal making. The process was carried out in mounds or piles on the ground. It was necessarily wasteful, the average maximum yield being not more than 55 per cent, as compared with a yield of 60 to 65 per cent from the same coal in bee-hive ovens. The bee-hive coke derives its name from the round structure in which it is produced, which literally follows the arrangement and shape of a bee-hive. An opening is provided at the top, through which the coal is charged and through which the products of combustion escape. An arched door at the base of the oven admits air for combustion and permits the coke to be watered and drawn.

The coking property of a coal is dependent upon chemical composition rather than physical structure, and is determined by the ratio of hydrogen to oxygen. This ratio cannot be determined from the data supplied by a proximate analysis, but requires an ultimate analysis of the coal. From experiments carried out, it has been found that any coal with an H:O ratio over 50 per cent will coke. English investigators have noted quite a variation in the oxygen content of coal from the same seam. Some analyses (Private Notes) indicate that the portion of the coal termed "Clarain" has a much higher oxygen content than the portion identified as "Durain." Since the "Clarain" is much more friable than the "Durain," it follows that in such seams the smaller screen sizes of the prepared coal may contain more oxygen than the larger sizes. Analyses show that in some seams the smaller sizes do contain more oxygen than the lump coal. Since any change in oxygen content may change the H:O value, and since the latter value is a measure of the coking property of the coal, then we might expect that in some coking coals, certain sizes of the run-of-mine product may have no coking property. Delamater found this to be true in one instance (Personal Communication).

Oven Test to Determine Coking Properties

However, instead of the scientific disposition of whether a coal is coking or non-coking, the obvious thing to do is to make a practical oven test of the coal under consideration. The coking property however, is of secondary consideration if it has been revealed by chemical analysis that the coal contains ash, sulphur, or phosphorus, in excessive amounts. The following analyses represent the chemical requirements for the various kinds of coke: (ABC of Iron and Steel; 2nd Ed., pp. 68—The Manufacture of Bee-Hive Coke, by J. L. Sherrick.)

	Acid Bessemer per cent	Basic open hearth per cent	Foundry per cent
Volatile matter	0.58	0.48	0.52
Fixed carbon ..	88.80	88.27	88.95
Ash	10.62	11.25	10.53
Sulphur	0.87	0.85	0.75
Phosphorus ...	0.012	0.065	0.020

The bee-hive coke oven process is at best a very wasteful one since the valuable compounds of the volatile matter are allowed to escape. One writer has stated it to be a case of money actually "going up in smoke." The by-product system recovers these valuable materials, and for this reason the by-product oven almost completely replaced the bee-hive process in this country.

The first by-product coke was made in the United States in 1893, in ovens built by the Semet-Solvay Company, at Syracuse, N. Y. This process has three major advantages over the bee-hive process. 1—Recovery of valuable by-products. 2—Greater yield of coke per ton of coal (at least 15 per cent greater.) 3—Many coals not suitable for coking in bee-hive ovens become available for by-product ovens by mixing with other coals.

Most metallurgical coke is used as a blast furnace fuel. The value of a coke for the smelting process depends upon its physical structure, as well as chemical purity. A coke must be sufficiently dense and strong to resist breakage during handling and during its descent through the furnace. The stress laid on physical strength however, is probably excessive. Very ordinary cokes will withstand crushing stresses of several hundred pounds per square inch. On the other hand, the pressure of the stock column in a blast furnace never exceeds 40 lbs. per square inch. (Principles, Operation, and Products of the Blast Furnace, 1st Ed. pp. 170—J. E. Johnson, Jr.) It is an undeniable fact however, that soft coke causes a high fuel consumption per ton of pig iron produced. But this is probably due to the fact that soft cokes do not resist solution as well as the denser cokes.

Blast furnace operators are able to say definitely just what quality of coke they desire from the standpoint of chemical constitution, but as yet they have been unable to state their requirements in a coke regarding physical characteristics. This may be due to the fact that suitable tests are yet to be devised which actually evaluates coke in regard to physical condition. There is no test known which will accurately predict the behavior of a coke in the furnace. Apparent and specific gravity tests are made, and also the so-called "shatter test" to determine the resistance to breakage. These tests however, are valuable only inasmuch as they show the comparison of one coke with another coke. Laboratory tests to determine the reactivity of coke are not all that could be desired. This is a matter which merits diligent research. Furnace operators desire a coke which is hard, but not too hard. They are unable to say just what density they require, and evidently coke oven operators are unable to produce a coke of constant density, even when operating on the same coal mixture.

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*Metallurgical Department, The American Rolling Mills, Ashland, Ky.

Ash Content

Many blast furnace operators think that a coke must contain at least eight or nine per cent ash, in order to give it proper strength. One furnaceman informed the writer that in one instance he actually demanded a higher ash content in the coke from his ovens because the coke was too soft. On the other hand, the writer recently inspected a sample of coke which analyzed six per cent and which was sufficiently dense for blast furnace use. It had identically the same structure as many cokes which contain from 10 to 12 per cent ash. The charge column in a blast furnace is partially supported by the upward pressure of the blast, the friction on the walls of the stack, the reaction of the bosh walls, and by flotation in the liquid iron and cinder in the hearth. The amount of strength thought necessary in coke has undoubtedly been overestimated.

Combustibility has come in for its share of attention as a physical quality of blast furnace coke. This is a subject which has not received the amount of attention it merits. Some writers have attempted to correlate combustibility with chemical composition, particularly ash content. It seems however, that other things being equal, a furnace will consume a constant amount of fuel in a given period of time, regardless of the ash content of the fuel. For rapid combustion however, a coke should be in the form of large lumps, and should have a well defined cellular structure.

The chief impurities in coal, considered as a metallurgical fuel, are ash, sulphur, and phosphorus. The percentage of ash in the coke produced will be approximately one and one-half times the ash content of the coal used, the same is true of phosphorus. During distillation, a portion of the sulphur escapes as hydrogen sulphide, or carbon-bisulphide. The portion thus eliminated ranges up to 30 per cent of the whole. (The Blast Furnace and the Manufacture of Pig Iron—Robert Forsythe, 3rd Ed. pp. 81.) The value of a coke as a blast furnace fuel may be estimated as follows: (Ibid, pp. 85.)

Available Units of Carbon

Since a fuel is primarily intended to furnish heat it is evident that its evaluation must be based upon the available units of carbon which it contains. The available carbon is that which is left after deducting from the fixed carbon the amount necessary to melt the slag formed from the ash and sulphur of the fuel, and the stone needed to flux them. In order to estimate the approximate amount of fluxing stone needed, it is convenient and sufficiently accurate to consider that the ash requires double its weight of stone, and the sulphur three and one-half times its weight. The weight of the ash, plus the weight of the sulphur, plus the weight of the slag forming portion of the calculated limestone, will give the weight of the slag formed by the fuel. If the slag requires 25 per cent of its weight in carbon to melt it, then 25 per cent of the weight of the slag deducted from the total fixed carbon will leave the available carbon. For example a coke having the following analysis

Fixed carbon	84.40
Ash	12.00
Sulphur	1.15

will require (2x12) plus (3.5x1.15) equals 28 per cent stone. If the stone contains 43 per cent CO_2 it will contribute 57 per cent to the slag. Hence, the weight of the slag per 100 lbs. of fuel will be, 12 plus 1.15 plus (28x.57) equals 29.11 lbs.; 29.11 x .25 equals 7.28 the carbon used by its own slag. Then, 84.40 minus 7.28 equals 77.12 available carbon.

The relative powers as heat producing agents, of fuels, and consequently their relative values to the metallurgists, are in proportion to their respective amounts of available carbon. To determine their respective cash values, it is only necessary to estimate their relative costs, based on the amounts of available carbon and the price paid per ton, and then to deduct the cost of the stone needed to flux the ash and sulphur. In comparing the smelting values of various fuels, the only safe basis of comparison is that of the available carbon.

It is evident from the foregoing that the relative value of by-product coal may be established, if the analysis of the coal is known. However, there is generally a variation between the theoretical and actual analyses of coke produced from any given coal. In a test covering 20 days, the writer noted an average variation of 1.75 per cent ash. But since the variation was probably due to imperfect sampling, or operating conditions, the error may be assumed to be relative and more or less constant, and there seems to be no reason why by-product coals could not be evaluated in this manner. It should be remembered though, that such a method is based entirely upon the value of the coke delivered to the blast furnace. No attention is given to by-product yield. This would be constant though when using the same coal and operating the ovens in the same manner. Any such method of evaluation must be based upon a constant coke yield and a constant amount of volatile matter in the coke produced.

In the foregoing paragraphs no attention has been given to moisture. It is obvious that when coke is pushed from the ovens it contains no moisture. Water is purposely added in order to lower the temperature of the coke and prevent the combustion of carbon. A prolonged quenching period will of course increase the moisture content of the coke. This automatically lowers the percentage of fixed carbon, and in the blast furnace causes an increase in the amount of fuel necessary to produce a ton of iron.

Wrought-Iron and Steel Pipe and Tubing Standardization

The ever increasing use of wrought-iron and wrought-steel pipe for industrial and domestic uses, as they are integral parts of many manufacturing processes and from the arteries and veins of modern plumbing and power systems, makes it more and more desirable to have nationally recognized standards of design, dimensions and materials for such pipe and tubing.

A large amount of preliminary work has already been done in this direction by the American Society for Testing Materials, the American Society of Mechanical Engineers, the National Committee on Metals Utilization, and other national organizations, but in order to develop unified nationally recognized standard specifications, all existing standards and specifications will now be thrown into a common pool and a representative sectional committee containing delegates from every important interest concerned, will carry on a large program of standardization under the auspices of the American Engineering Standards Committee.

Observations on Testing of Sheet Steel

A Comparison of the Testing Methods and the Internal Defects Noted in Deep and Extra Deep Drawing of Sheet Steel. Segregation, Inclusions, etc., Considered

"AUTOSHEET"

A SURVEY of the literature pertaining to sheet steel has shown that the majority of such articles published up until a few years ago dealt only with general mill practice, and gave very little technical information. However, as the demand for sheet steel having better drawing properties increased with the growth of the automobile and similar industries, it has necessitated manufacturing developments for its closer control. These developments have been so rapid that in the most cases data has not been tabulated and outlined in literature, which would be of interest to those using sheet products.

In the effort to control the results of such developments, physical tests, such as the ultimate tensile strength, proportional limit, ductility and hardness were determined, all of which were relative only. While these physical tests of sheet metal show certain relations or comparisons between themselves, they could not take into account the internal as well as external defects which can be expected in the general run of commercial sheet steel. By these internal defects is meant segregations, inclusions and variation in grain size, and those of external defects as surface finish, all of which will be taken up later.

However, with the application of microscopic studies to these steels, it has allowed definite conclusions to be drawn regarding the relation of their structure to such physical tests as mentioned above.

Before these relations are discussed it may be of interest to briefly outline the various physical tests that have been applied together with their relative importance.

Physical Tests

The various methods for testing so-called "temper" or drawing quality of sheet steel are numerous, and in most cases have to be selected, based on the fact whether these tests are being made for research or against production.

The ultimate tensile strength and proportional limit as determined by the Tinium Olsen or Riehle testing machines are of interest, but from the authors point of view do not enter into consideration where rapid yet fairly accurate results are necessary.

While the Shore scleroscope test has been used to a certain extent to determine "temper" or hardness, such figures indicate the resilience of the sheet only; Such tests will show extreme variations, due to the different surface finishes, even though such sheets may possess the same drawing characteristics. For example: Automobile radiator shells which are to be nickel plated require a sheet ductile enough for a deep draw, yet possessing a fairly smooth surface at the completion of its draw, thus avoiding the added expense of grinding. Smooth finishes are usually obtained by one to four final cold roll passes, and the hardness of such sheets if determined on the Shore scleroscope will show wide variations, depending upon the hardness of the outer surface increased in relation to the amount of final cold rolling.

On heavy gauge sheet steel the Brinell hardness test is sometimes used. While no definite data is available, it appears that such readings on deep drawing sheets from 18 to 20 gauge are of doubtful value. This is concluded from the fact that in testings a soft sheet is excessively crushed, and it becomes necessary to pile two or more pieces in order to prevent increased hardness, which might be caused by the resistance of the supporting anvil. Unless these pieces are perfectly flat, a high percentage of errors is to be expected, due in all probability to slippage between sheets.

The Rockwell hardness test has its advantage over the scleroscope and Brinell tests, in that the minor load which is always applied first breaks through the oxide or scale which may be on the surface, and allows the major load to read a closer "true" hardness or "temper" of the sheet. However, it has been noticed in testing deep and extra deep drawing sheet, that an appreciable "drift" occurs after this major load has been applied which makes the results obtained vary according to the personal factor of time which elapses between the full application of the load and its release.

One of the common defects of sheets is the excessive grain growth near the surface with small grains at the center, a condition which will be discussed later. Rockwell tests made on such sheets will tend to show false readings, for the reason that the steel ball may penetrate only partially through the large grains, thus failing to read the hardness of the smaller grains, which will necessarily be higher. See Plate 1.

The Ericksen and Olsen ductility machines have many decided advantages which predict the grain size as well as the drawability. Not only do they show the depth of the draw at the point of fracture, but an examination of the resulting cup will show to a certain extent the resulting surface that can be expected, of forms or shapes having sharp radii.

Plate 2 shows the resulting cup of an extra deep drawing sheet steel and from inspection it will be noted that the point of fracture is not at any one point, but fractured completely around the dome. The appearance of the dome indicates a good grain structure which is confirmed by the photomicrograph.

Plate 3 indicates good drawing sheet steel with the fracture occurring only partially around the dome, and its surface indicating a slightly coarser grain structure than is shown in Plate 2. The photomicrograph of this steel bears out these conclusions.

Plate 4 shows the cup from material which appears to be of a still coarser grain structure as indicated by the "orange peel" effect with the fracture occurring within a small area. This conclusion is also borne out by the photomicrograph.

The Olsen testing machine has the additional feature over the Ericksen in that it shows the pressure required to make a cup of any given depth. The depth

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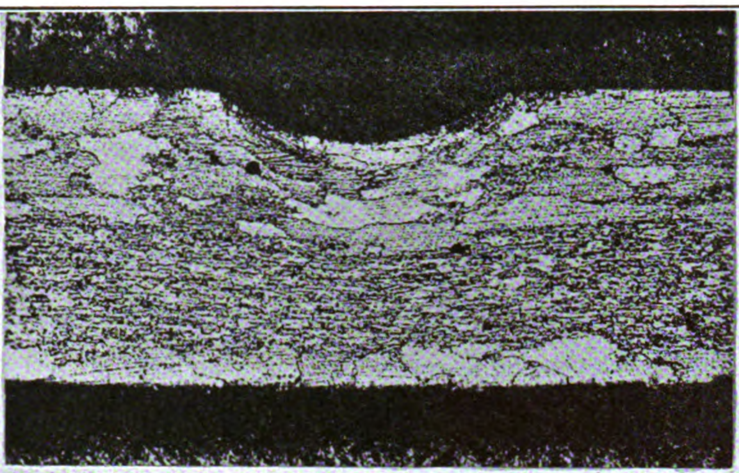

Plate 1 X40

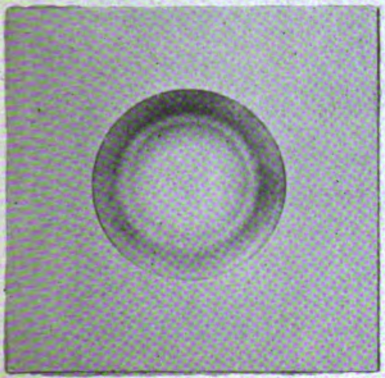

Plate 2 X1

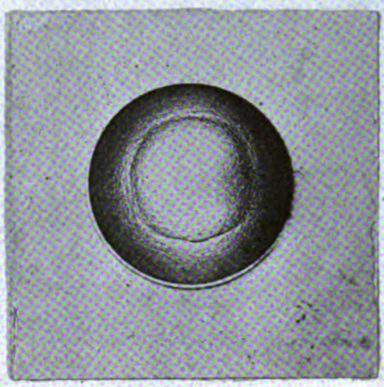

Plate 3 X1

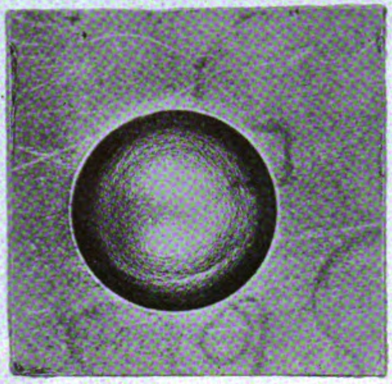

Plate 4 X1

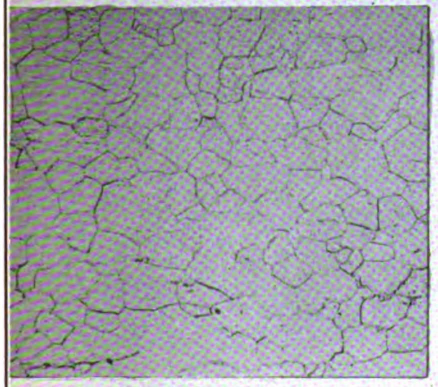

Plate 2 X100

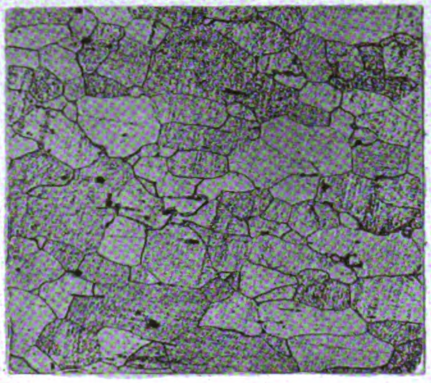

Plate 3 X100

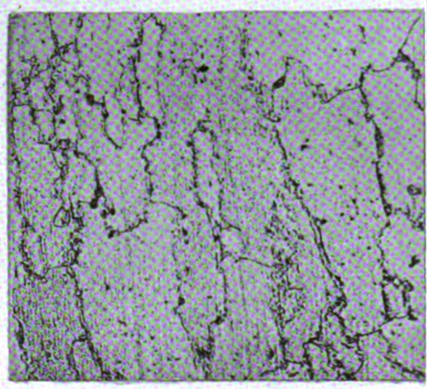

Plate 4 X100

of its draw is measured in inches as compared to that of the Ericksen which is measured in millimeters. Either of these two machines are rapid and a comparison of the ductility and nature of the draw of the sheet as compared to the percentage of breakage in the press, together with its microstructural study appears to give the most practical and conclusive results thus far obtained. These checks involve and make due allowances for practically all commercial internal as well as external defects previously mentioned as existing in deep and extra deep drawing steels.

The usefulness of the microscope and its importance in conjunction with the physical results is gradually becoming more apparent. The Olsen and Ericksen ductility machines have the advantage of easy yet rapid performance, while the microstructural studies require laborious preparations and highly technical men for its correct interpretation. However, in spite of this, microscopic studies readily explain the true condition of the steel, and usually can account for the variations in the results obtained by any of the foregoing physical tests. The expenditures necessary for these microscopic studies are well repaid to those who demand a uniform product.

No doubt you will recall concerns who would have been repaid by maintaining a metallurgical control of this nature on their sheet steels rather than allowing not only a high percentage of breakage with a low reclaimation value, but also a loss in output of finished parts.

Commercial Defects

To more fully explain these microstructural studies and their relation to some of the above mentioned tests and drawability in the press, it may be of interest to outline the common defects of sheet metal as revealed by the microscope.

In general these can be classified under two groups, the first covering external or surface defects, and the second, internal or structural defects.

The external or surface defects are of importance where an exceptionally good finish is desired, but the authors have not as yet made sufficient investigation along these lines to permit conclusions to be drawn at this time.

The internal or structural defects present, directly influence the drawing properties. The principal defects to be commercially encountered can be classified as follows:

Segregations, especially around grain boundaries.

Inclusions, as slag and sulphides.

Insufficient annealing of the pack partially relieving rolling strains.

Heterogeneous grain structure due to excessive grain growth near surface of the sheet.

Segregations

Due to the natural laws which govern the solidification of liquid metals, certain constituents such as phosphorus and sulphur are found to be more or less segregated near the "pipe" of the ingot. While this "pipe" is generally cropped off, sheet bars made from the ingot adjacent to this section will show a difference in composition than from sheet bars made from the bottom of the same ingot. Regardless of the refinement of these bars which show segregation, the

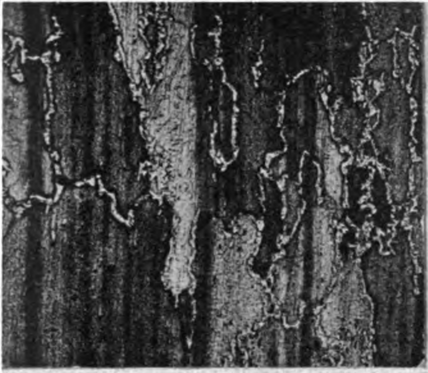
Plate 5 X100

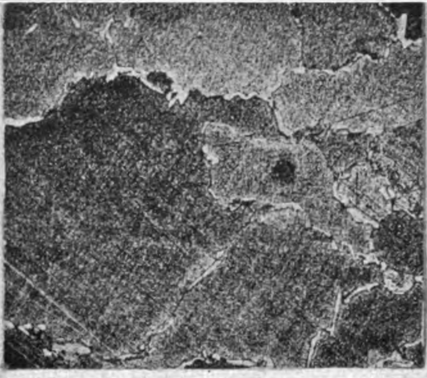
Plate 6 X100

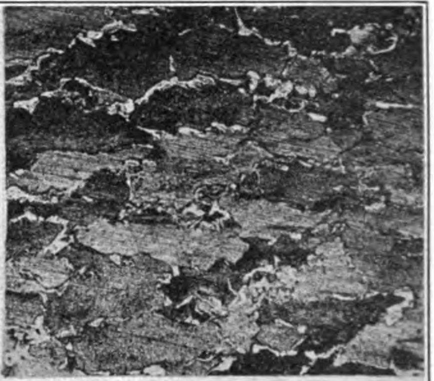
Plate 7 X100

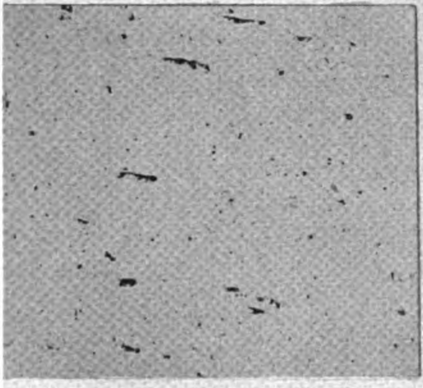
Plate 8 X100

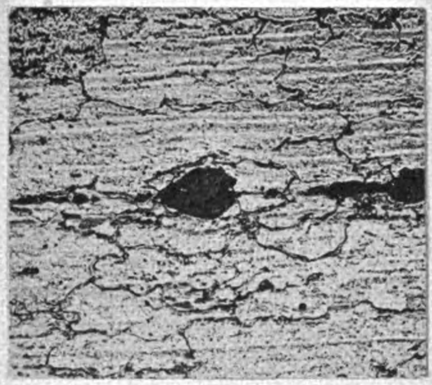
Plate 9 X100

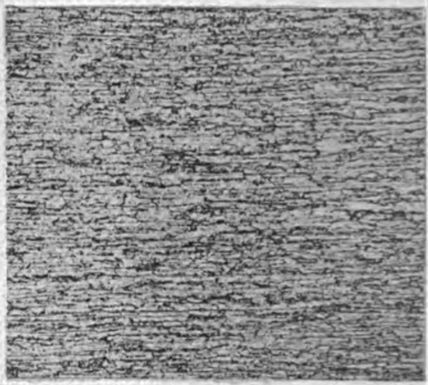
Plate 10 X100

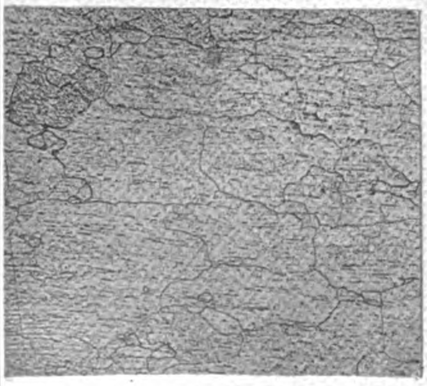
Plate 11 X100

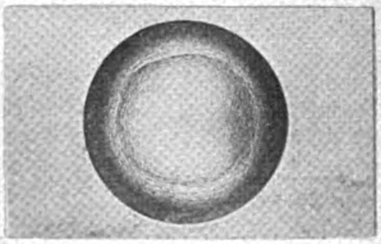
Plate 12 X1

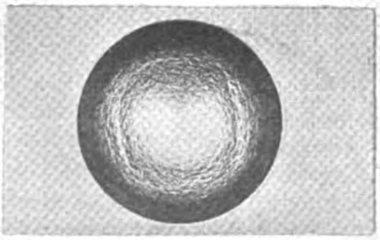
Plate 13 X1

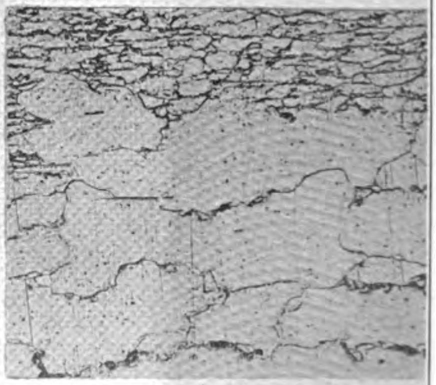
Plate 14 X100

resulting sheets invariably produce a high breakage of parts. Plate 5 shows such segregation completely surrounding the ferrite grains. The former case (Plate 5) is rather an exception, while the latter (Plates 6 and 7) are typical of this defect.

The ultimate tensile strength and elongation as well as Olsen ductility test of the material as represented by Plate 5 comes within the range of good drawability, yet it could not account for failure during forming, and the microscopic examination readily explained this difficulty.

Inclusions

Within the past few years the processing of sheet steel has been so exacting that in deep and extra deep drawing sheet steels, inclusions of any appreciable amount are rarely found. In most cases when found they are usually well distributed and seldom influence the drawing properties of the material. Plants 8 and 9 are typical examples of manganese sulphide inclusions.

Insufficient Annealing of Pack

One of the most important defects encountered in sheet steel and which greatly concerns its drawing properties is the insufficient annealing of the packed or piled sheets in the annealing box. The compactness of this mass necessitates a soaking anneal, and in the event that the flames striking the box is of a rash rather than a soaking heat, it results in an overanneal on the outside of the pack, while the inside or central portion is underannealed. Consequently, the structure of the center of the sheet shows small elongated ferrite grains together with rolling strains which have not been relieved, as illustrated by Plate 10. In contrast to this is the normal or enlarged grain structure found in the outer edge of the sheet as shown in Plate 11. Consequently, a fairly wide range of ductility occurs in this kind of material, and the breakage is variable, depending on whether the sheet as a whole is formed or blanked and drawn into smaller parts.

Olsen ductility tests clearly contrast without the necessity of microscopic examination, this difference in structure. Plates 12 and 13 show the cups made from sheets taken from the middle and top of the pack respectively. It will be noted in Plate 12, the smoothness of the cup indicating fine grain structure, while Plate 13 shows a coarse or so-called "orange peel" effect denoting large grain structure.

Heterogeneous Structure

By this we mean sheets showing excessive grain growth near its surface and small grains at the center as shown in Plate 14. This condition can probably be attributed to cold rolling. In cold rolling the sheet to the gauge desired, uniform deformation through-out does not take place with the result that the outer portion having been critically strained, tends to show abnormal grain growth. A sheet showing such a structural variation throughout its thickness tends to draw unevenly. As previously mentioned, Rockwell tests will not indicate the true "temper" of such a material, and Olsen ductility tests will show an "orange peel" effect of coarse dome with a shallower cup. In cases of this nature, a microscopic examination is the only reliable means of determining the cause of failure.

Conclusions

While the physical testing machines as outlined above have their advantages depending upon the kind of results desired, the Olsen ductility machine appears to be the most rapid yet fairly accurate means of checking the drawability of sheet steels. Not only does it indicate the ductility but will give an idea as to the grain structure.

The internal defects, the most common of which are: Segregations, inclusions, insufficient annealing and heterogeneous grain structure, are easily determined by microscopic examination.

The table attached merely gives typical examples of the various deep and extra deep drawing sheet steels as illustrated in the foregoing article and are the result of hundreds of samples on which the conclusion is based.

Material represented by plate No.	Ultimate tensile strength	Per cent elongation in 8 in.	Rockwell hardness "B" scale	Brinell hardness 10 mm ball	Scleroscope hardness (univ. hammer)	Pressure at 250"	Pressure at fracture	Depth of fracture	Drawability in press	Failure due to	Quality of sheet
2	40,500	26	37.0	75	D22 to D24	2200	3200	.377	very good	none	extra deep drawing
3	43,600	24	36.0	89	D22 to D24	3100	4500	.365	good	none	deep drawing
4 } 5 }	43,280	21.8	34.0	77	D19 to D21	2500	4800	.350	very poor	segregation	deep drawing
6	40,400	26.4	38	78	D19 to D21	2600	3900	.355	very poor	segregation	deep drawing
7	35,500	18.6	29	73	D19 to D21	2700	4000	.360	very poor	segregation	deep drawing
9	42,150	20.3	27	76	D19 to D21	2400	4000	.378	very poor	inclusions	deep drawing
10	40,400	25.7	42	81	D19 to D21	2540	3890	.315	poor	unrelieved rolling strains	deep drawing
11	41,075	25.6	35.5	77	D19 to D21	2350	4250	.364	good	none	deep drawing
12	Refer to Plate 10										
13	Refer to Plate 11										
14	42,250	22.4	3.90	76	D19 to D21	2500	3700	.345	very poor	excessive grain growth	deep drawing

In conclusion it is the belief of the authors that the Olsen ductility tests together with microscopic examinations when compared with the drawing of this steel in the press, offer a most complete means of studying and recording deep and extra deep drawing sheet steel.

Loss from Sloss-Sheffield Furnace Decreased

Blast furnace operators are greatly interested in the performance of the new No. 2 city furnace of the Sloss-Sheffield Steel & Iron Company, due to the very small loss in flue dust. Formerly there was a loss of 400 lb. of ore and coke for each ton of pig iron, but at present the loss is immaterial. Other modifications in the rebuilt furnace, it is claimed, make it possible to produce better iron at a lower cost than at the average blast furnace.

Refining Steel in the Molten State*

For the Production of the Best Steel the Melting Should Be So Conducted that All Oxygen Will Be Eliminated in the Solidified Metal. Means for Deoxidizing Bath Are Concisely Stated

By G. A. DORNIN†

STEEL may be largely known by the slag under which it is produced and protected from outside influence until cast. There are only three major stages or divisions of steel making, each having its own special effect or effects on the character of the metal. These are:

1—Melting or molten stage.
2—Ingot or solidification stage.
3—Working or treatment stage.

The first stage covers steel making up to the point where it is poured into molds and solidification begins. It determines the analysis, freedom from extraneous or unwanted matter such as dirt, sonims and oxides and governs the method by which the ingot or casting forms. The second stage covers the going of the molten into the solid and determines the location of the shrinkage volume and the uniformity of the ingot or casting.

The third stage includes the working (rolling or forging) of the ingots into some useful shape or form and the treatment of these forms either by heat or otherwise to produce certain desired results. The effects of this third stage are largely on the crystal size and the form of the carbon, hence entirely on physical characteristics.

Steel making processes are almost universally known by their method of melting and treating while molten.

The best known processes are: 1—Crucible, 2—Bessemer, 3—Open-Hearth. Many may say that the electric furnace is a fourth process, but I prefer to consider it as a special form of open-hearth, the main difference being that the heat is furnished by the electric arc instead of by the combustion of fuels.

In the crucible process wrought iron or steel scrap of pre-determined analysis is melted in a clay or graphite crucible. This protects the molten metal largely from outside influence and gives a chance therefore to produce a pure clean product. The only sources of contamination are the erosion of the crucible, the oxides present in the charge and the air in the pot itself. These latter causes of oxidation, while slight, are, as a rule, sufficient to make it necessary to deoxidize and refine before the melt is ready to cast. The process is limited to melting in small quantities, is expensive and the results are so closely approximated by small electric furnaces that in this country it is largely dying out.

The first process which permitted the making of large tonnages of steel was the Bessemer process. This consists in blowing air through molten pig iron thus oxidizing out of the bath carbon, silicon, and manganese. Toward the end of the blow the bath is deoxidized with manganese or speigel, carbon, silicon and manganese or any of these are returned to the steel in the desired amounts usually in the ladle when the heat is tapped. The process is worked either acid or basic, the latter getting rid of phosphorus as well as the other elements.

Closely following the Bessemer process came the open-hearth in which pig iron and steel or iron scrap are melted down in a regenerative furnace, the burning out of unwanted elements being accomplished by additions of iron ore (oxide) or of scale or cinder carrying a high percentage of iron oxide. In some cases the oxidizing effect of the flame is sufficient to do all that is necessary, but in most cases ore is added. The acid open-hearth process does not remove either phosphorus or sulphur while the basic open-hearth process does remove both and if properly run to very low percentages.

Best Steel Contains Least Oxygen

It is the writer's firm belief that practically all evils of steel making can be traced to the presence of oxygen in some form in the solidified product, and that the best steel is that which contains the least oxygen. This is a rather sad fact to face because in all of the steel making processes except the crucible process oxygen in some form must be introduced into the bath to burn out the elements not wanted in the final product; so that the problem resolves itself into a means of getting oxygen out of the bath after it has performed its function.

This can only be done by causing the oxygen in the bath to form compounds not soluble in the bath but still fusible at the bath temperature so that by the laws of colloidal chemistry they will collect themselves into particles which are large enough to float up out of the bath into the slag. Having gotten them into the slag, this must be in such condition that it will retain these unwanted products of oxygen, and not return them to the bath. The causing of oxygen, soluble in the bath, to take a non-soluble form is commonly called deoxidation. Sometimes the term degasification is added, but to my mind deoxidation is comprehensive enough to cover both.

Refining means the getting out of the bath by flotation, the products of deoxidation. Contamination means the return to the bath chemically or mechanically of elements which have previously been removed by melting, deoxidation and refining.

These three phases deoxidation, refining and contamination, the causing of the first two to take place and the prevention of the third govern the percentage of oxygen in the final product, and hence the ability to properly carry out these three phases in any steel making process rates the ability of that process to make sound clean steel.

At relatively low melting temperatures, iron, silicon, manganese and phosphorus have a greater affinity for oxygen than has carbon, while at relatively high melting temperatures carbon has a greater affinity for oxygen than any of these and hence will reduce the oxides of any of them.

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*Abstracts from a paper delivered at the Convention of American Society for Steel Treating, Detroit, September 20, 1927.

†Consulting engineer, The Gathmann Engineering Company, Baltimore.

The major contaminating factor affecting a bath of steel that has been deoxidized and refined is the iron oxide present in the slag. It is only through this iron oxide that reoxidation can take place, FeO in the slag being oxidized to Fe_2O_3 by the flame which on coming in contact with the bath along the slag bath line breaks up again into FeO, oxidizing iron in so doing. This FeO is soluble in both bath and slag, and if a bath practically free from FeO is left in contact with a slag carrying FeO the bath quickly takes up FeO until the slag and the bath are in equilibrium with reference to FeO. The total amount of contamination therefore that can take place has a direct relation to the total amount of FeO present in the slag to accomplish this undesired result, and the time the slag and bath are left in contact with each other; because all mass action takes time.

Silicon as a Deoxidizer

The best method of deoxidizing a bath of steel is by the introduction of silicon which reduces FeO in the bath to form SiO_2. This is infusible at the bath temperature, but on formation finds itself in the presence of FeO with which it forms slag globules fusible at bath temperatures which coalesce and grow until they float up into the furnace slag. Silicon therefore performs a double function in the removal of FeO from a bath of steel in that it reduces FeO to form SiO_2 and this SiO_2 fluxes out still more FeO. It probably also fluxes out of the bath MnO and MnS. Manganese on the contrary while it is a deoxidizer has a lesser affinity for oxygen than has silicon and also it has no effect in the removal of FeO by fluxing. Aluminum is the most powerful deoxidizing agent at our command. It probably has a fluxing as well as a reducing effect. Its cost and the difficulty of getting it to function at the slag-bath line, due to its lightness, largely limits its use to a final corrective added when the steel is tapped into the ladle after the major part of deoxidizing and refining has been carried out in the furnace with the cheaper and more easily handled elements.

Carbon functions as a deoxidizer only at high bath temperatures. As its oxide is a gas it is better than any of the other deoxidizers, because the others all leave solid non-metallics, which take time to get rid of by flotation, and are never completely eliminated. It is, as a rule, made use of, to some extent, in both acid and basic open-hearth processes, and very largely in the basic electric process, where two slags are taken, the first or oxidizing slag being removed, and a second or refining slag free from iron oxide being formed, usually of lime and carbon.

Contamination

The total amount of contamination that can take place has a direct relation to the total amount of iron oxide present in the slag. It is also governed by the relative freedom of this iron oxide to do its work of contamination. This is greater for basic slags than for acid slags and for this reason acid slags are less oxidizing than basic slags. It is also possible with acid slags to deoxidize both bath and slag; while a basic slag carrying phosphorus and sulphur, if the slag is deoxidized, there is always danger of deoxidizing these two elements, and driving them back into the bath, and this is almost certain to happen if this slag deoxidation is carried too far.

One must therefore rate steel made under an acid slag as cleaner than steel made under a basic slag, unless the basic slag is a second slag free from iron oxides, in which case one would expect to find cleaner steel under a slag which carries no iron oxide, to do the work of contamination. Furthermore, the slag free from iron oxide prevents any transferring of oxygen from flame to bath, and this always goes on to some extent when there is iron oxide in the slag. With this slag blanket free from iron oxide, one can prolong the refining period to the extent desired, and the steel made under this type of slag should be cleaner than steel made under an acid slag. There is also a limiting feature in the deoxidizing of the bath and slag in an acid furnace; as this builds up silicon in the bath which may be above the percentage desired.

The electric furnace is an open-hearth furnace and as its cavity is not sealed oxygen must always be present in its atmosphere. Its temperature control is better than a gas-fired furnace and there is probably less oxygen present in its furnace atmosphere.

The various steel making processes according to their ability to make sound clear steel must therefore be rated as follows:

First—Crucible; because of absence of, and freedom from, iron oxides, all through the process.

Second—Open-hearth; because while the process depends on oxidation during melting it permits of deoxidation and refining at the end of melting.

Third — Bessemer; because its oxidation is greatest and no opportunity is given to deoxidize and refine, except to a limited extent and that largely in the ladle.

The various types of slag covering the bath and produced during melting must be rated as follows:

First—Slag free from iron oxides such as the second slag on a basic furnace

Second—Acid slags

Third—Basic slags carrying phosphorus and sulphur.

The writer's object in the presentation of this paper is to bring about a discussion of certain vital factors which govern good steel making. It is not offered as an addition to our present knowledge of the art, but is an attempt to analyze the subject to its basic elements.

John Fritz Medal Awarded

The John Fritz Gold Medal for 1928 has been awarded to Gen. John J. Carty, vice president American Telephone & Telegraph Company, New York, for notable achievement in telephone engineering. The award was made by a board of 16 representatives of the American societies of civil, mining and metallurgical, mechanical, and electrical engineers. This medal is awarded once a year for some outstanding scientific or industrial achievement, and is a memorial to John Fritz, late of Bethlehem, Pa., at one time a leader in the American iron and steel industry. The presentation of the medal will take place in February, 1928, at the annual meeting of the American Institute of Electrical Engineers, in New York. General Carty was appointed chief engineer of the American Telephone and Telegraph Company in 1907. His notable achievement was the construction of the transcontinental line, 3400 miles long, opened to commercial use January 25, 1915.

Patents Covering Pipes and Tubes

As There Has Been Much Activity in the Manufacture of Tubular Products, This List Was Compiled with the Hope that It May Be Helpful to Those Investigating the Subject

By VICTOR S. POLANSKY

PART II

Mannesmann, Max. Machine for Rolling Tubes. (721,212.)

Mannesmann, Max. Manufacture of Seamless Tubes. (361,954.)

Mannesmann, Max. Manufacture of Seamless Tubes. (361,959.)

Mannesmann, Max. Manufacture of Seamless Tubes. (361,960.)

Mannesmann, Max. Manufacture of Seamless Tubes. (361,961.)

Mannesmann, Max. Manufacture of Seamless Tubes. (361,962.)

Mannesmann, Max. Manufacture of Seamless Tubes. (361,963.)

Mannesmann, Reinhard. Manufacture of Seamless Tubes. (361,955.)

Mannesmann, Reinhard. Manufacture of Seamless Tubes. (361,956.)

Mannesmann, Reinhard. Manufacture of Seamless Tubes. (361,957.)

Mannesmann, Reinhard. Manufacture of Seamless Tubes. (361,958.)

Mannesmann, Reinhard, and Mannesmann, Max. Mechanism for Making Seamless Tubes. (389,585.)

Marshall, Charles A. Seamless Tube and Process of Making the Same. (377,318.)

Mercader, Camille, and Byrnes, Clarence P. Method of Making Seamless Tubes or Hollow Articles. (717,886.)

Meyer, George U. Arbor. (441,889.)

Meyer, George U. Process of Drawing Seamless Tubes. (441,888.)

Morse, Alonzo Clay, and Lewis, Harry Richard, Jr. Process for Seamless-Tube Drawing. (1,450,699.)

Nathanson, William, and Behm, Jack. Method of Making Seamless Connecter Tubes. (1,608,180.)

Nathanson, William, and Behm, Jack. Method of Making Seamless Pipe Connections. (1,520,764.)

Neuberth, George E. Machine for Making Seamless Tubing of Metal, Pulp, or Other Materials. (1,285,328.)

Neuberth, George E. Machine for Making Seamless Tubing of Metal, Pulp, or Other Materials. (1,330,489.)

Nicholson, John H. Conical Rolls for Piercing, Expanding, or Cross-Rolling Metal Billets or Tubular Blanks. (765,986.)

Nicholson, John H. Mechanism for Making Tubes from Billets. (628,024.)

Nicholson, John H. Method of Making Seamless Tubing. (870,246.)

Nicholson, John H. Piercing and Expanding Mill. (718,723.)

Nicholson, John H. Tube-Rolling Mill. (769,709.)

Nowak, Adolph Alexander Karl. Tube-Rolling Mill. (1,036,309.)

Offutt, John W. Apparatus for Rolling Seamless Tubes. (1,100,696.)

Offutt, John W. Method of Making Seamless Tubes. (1,040,569.)

Offutt, John W. Rolling-Mill. (741,702.)

Parker, Benjamin F. Reeling Device. (1,040,748.)

Patterson, Peter. Seamless-Tube-Drawing Mechanism. (741,369.)

Peters, Mathias. Manufacture of Tubes. (948,961.)

Peters, Mathias. Rolling-Mill for Producing Tubes. (954,880.)

Peters, Mathias. Rolling-Mill for Producing Tubes. (970,263.)

Peters, Mathias. Steel Alloy for the Rollers of Pilger Rolling Mills. (1,558,918.)

Platt, Irving G. Apparatus for Making Seamless Tubes. (405,115.)

Pry, John C. Tube-Rolling Mill. (851,435.)

Rabold, George, Sr. Manufacture of Seamless Tubes. (1,412,196.)

Reimann, Robert, and Parselle, Absalom Percival. Manufacture of Seamless Tubing. (1,213,539.)

Reinhard, Henry. Manufacture of Metal Tubes or the Like. (989,643.)

Roeckner, Martin. Manufacture of Seamless Pipes. (1,610,593.)

Selkirk, William M. Mechanism for Rolling Tubing. (1,020,455.)

Simpkins, Frank E. Apparatus for Rolling Seamless Tubes. (1,141,425.)

Simpkins, Frank E. Mandrel Stripping and Cooling Mechanism. (1,141,426.)

Simpkins, Frank E. Manufacture of Seamless Tubes. (1,141,424.)

Simpkins, Frank E. Tube-Rolling Mill. (1,141,427.)

Steifel, Ralph C., and Nicholson, John H. Apparatus for Rolling Tubing. (923,726.)

Stiefel, Ralph C. Mechanism for Expanding or Enlarging. (605,027.)

Stiefel, Ralph C. Mechanism for Making Tubes from Metallic Ingots. (551,340.)

Stiefel, Ralph C. Method of Making Seamless Tubes. (1,474,800.)

Stiefel, Ralph C. Rolling-Mill. (774,795.)

Stiefel, Ralph C. Rolling-Mill. (774,796.)

Stiff, Wm. C., and Bennett, Herbert B. S. Manufacture of Seamless Tubes. (340,526.)

Stüting, Heinrich. Tube-Rolling Mill. (961,818.)

Stüting, Heinrich. Tube-Rolling Mill. (1,040,812.)

Tasker, Stephen P. M. Machine for Making Tubes from Hollow Ingots. (331,571.)

Tasker, Stephen P. M. Machine for Making Tubes from Hollow Ingots. (331,572.)

Tasker, Stephen P. M. Machine for Making Taper Tubes from Hollow Ingots. (331,574.)

Tasker, Stephen P. M. Machine for Making Taper Tubes from Hollow Ingots. (331,575.)

Tasker, Stephen P. M. Machine for Making Taper Tubes from Hollow Ingots. (331,576.)

Tasker, Stephen P. M. Machine for Making Taper Tubes from Hollow Ingots. (331,577.)

Tasker, Stephen P. M. Machine for Making Tubes from Hollow Ingots. (331,579.)

Tasker, Stephen P. M. Machine for Making Tubes from Hollow Ingots. (331,580.)

Tasker, Stephen P. M. Machine for Making Tubes from Hollow Ingots. (331,581.)

Tasker, Stephen P. M. Machine for Making Tubes from Hollow Ingots. (331,582.)

Tasker, Stephen P. M. Machine for Making Tubes from Hollow Ingots. (331,583.)

Tasker, Stephen P. M. Machine for Making Tubes from Hollow Ingots. (331,584.)

Tasker, Stephen P. M. Machines for Reducing Diameter of Metal Tubes. (175,522.)

Tasker, Stephen P. M. Mandrel. (331,570.)

Tasker, Stephen P. M. Mandrel. (331,578.)

Tasker, Stephen P. M. Mandrels for Rolling Metal Tubes. (151,323.)

Tasker, Stephen P. M. Roller-Mandrel. (331,573.)

Tasker, Stephen P. M. Rolling-Mill for Making Tubes. (382,017.)

Thust, George J. Clamping or Bar-Protecting Apparatus. (793,858.)

Thust, George J. Machine for Producing Seamless Metallic Tubes. (803,079.)

Thust, George J. Mandrel Mechanism for Rolling Billets into Tubes. (658,882.)

Thust, George J. Tube-Rolling Machine. (1,113,383.)

Weitz, Lewis H., Jr. Automatic Slacker for Seamless Tube Mills. (1,517,330.)

Wheeler, Elbridge. Composite Ingot for Producing Seamless Tubes. (368,175.)

White, Lyman. Machine for Forming Seamless Tubes. (432,463.)

White, Lyman. Machine for Rolling Seamless Tubes. (432,464.)

Whitehouse, Arthur T. Machine for Forming Seamless Metal Tubes. (227,462.)

Wikström, Malcolm Urban. Mechanism for Piercing Metallic Ingots or Billets. (1,022,524.)

Williams, Charles Francis, and Dicks, William. Apparatus for the Manufacture or Production of Weldless or Seamless Metal Tubes. (1,005,091.)

Windecker, Otto. Apparatus for Rolling Out Metal Tubes. (1,044,113.)

Winter, Emil. Mill for Manufacture of Tubes. (869,282.)

Winter, Emil. Mill for Manufacture of Tubes, etc. (869,283.)

Winter, Emil. Swaging-Mill. (869,284.)

Wolffgram, Ludwig. Making Long Seamless Thin-Rolled-Tubes Out of Warm Solid Blocks of Metal. (1,208,876.)

Wolffgram, Ludwig. Rolling-Mill. (1,352,493.)

Wolffgram, Ludwig. Rolling-Mill for Seamless Tubes. (1,234,245.)

Wolffgram, Ludwig. Seamless-Tube-Forming Mill. (1,185,270.)

Wootton, Robert, and Goold, Lewis W. Apparatus for Removing Mandrels from Metal Tubes. (562,778.)

Wootton, Robert. Machinery for Manufacturing Seamless Steel Tubes. (577,907.)

Wootton, Robert, and Others. Machine for Manufacturing Seamless Steel Tubes. (585,809.)

Wootton, Robert, and Hewitt, Benjamin. Means for Releasing Tubes from Mandrels. (547,234.)

Second Conference on Bituminous Coal

Official announcement comes from the Carnegie Institute of Technology in Pittsburgh that a second International Conference on Bituminous Coal will be held there during the week of November 19, 1928.

Decision to call a second congress of world scientists and fuel technologists has been made, it is announced, as a result of the widespread interest aroused throughout the world by the first Conference on Bituminous Coal held at the Carnegie Institute of Technology in November, 1926.

The first conference, which was devoted to discussions of the better utilization of bituminous coal, was attended by 1700 persons, including delegates from 13 different countries. Among distinguished European scientists who addressed the conference were Dr. Friedrich Bergius, Heidelberg, Germany; Professor Franz Fischer, director, Institute of Coal Research, Mulheim-Ruhr, Germany; General Georges Patart, Paris, France; Dr. Cecil H. Lander, director of fuel research, Dr. R. Lessing, consulting engineer, Geoffrey M. Gill, consulting engineer, and Harold Nielsen, London, England.

Although no definite program plans for the second conference have been made, it is expected that the 1928 session will cover the latest developments in obtaining substitutes for gasoline from coal, power from coal, low and high temperature distillation processes, smokeless fuel, gasification of coal, utilization of coal tar products, coal as a source for fertilizer, and coal in relation to the production of fixed nitrogen.

Dr. Thomas S. Baker, president of the Carnegie Institute of Technology, who called the first conference, visited Europe this past summer for the purpose of discussing phases of the second conference with eminent scientists in France and Germany. He plans to pay another visit to Europe in 1928 to invite speakers and delegates.

Skelp Mill at Glasgow, Scotland

At the works of Stewart & Lloyds, Ltd., at Mossend, Scotland, a universal mill is producing pipe strip, 3/16-in. thick, from slabs, weighing about 1680 lb. The output is about 33½ tons per hour. A set of rotary shears capable of cutting plates up to ⅝-in. thick, trims both edges of the plate at the same time, thus eliminating side-trimming as now performed. The maximum output of this mill is estimated to be 4700 tons of slabs, of which 90 per cent are finished plates. The largest output has been 480 tons per shift and the greatest production per hour approximately 74 tons. There are few men required to operate the mill.

Silica Gel a Medium for Drying Blast*

A Description of a Comparatively New Method for the Removal of Moisture from the Air and Its Effectiveness as Determined by a Test Under Operating Conditions

By EDWIN H. LEWIS, M.A. (Wishaw)

THE varying amount of moisture in the atmosphere and its effect on blast furnace practice has, for a long time, been of interest to ironmasters. It is 128 years since the first essay read to the "Friendly Association of Ironmasters" by the first president, Mr. Joseph Dawson, dealt with this subject.† Similarly, at the inaugural meeting of this institute, the Duke of Devonshire referred to the question as one of importance.

Figures showing the hourly variation of atmospheric moisture were given by Gayley in his classic paper before the institute in 1904.‡ No complete records over a long period of the moisture at Wishaw have been taken. Figures, however, taken in the West of Scotland confirm the relative variations, although in the Scottish climate the maximum moisture does not reach so high a point as that observed by Gayley. Half-hourly readings at Wishaw taken from the middle of April show the following maxima and minima:

	Grains per cu. ft. of Atmosphere	
1927	Maxima	Minima
April	4.70 (18th)	1.11 (27th)
May	5.88 (8th)	1.47 (10th)
June	5.57 (16th)	1.33 (12th)
July	6.51 (10th and 30th)	3.62 (16th)

The importance of these figures will be realized more readily if it is borne in mind that each 0.5 grain per cu. ft. in the blast represents about 10 lb. of water per ton of pig iron made. In order to trace the result of monthly variations on the output of pig iron, some figures were taken out, and showed in the case of one furnace 1.5 per cent, and in the case of another furnace 3.0 per cent, difference between the four summer and the four winter months.§ As a further test the average ratio ore/coal was calculated for ten pre-war years for all the furnaces in blast, and is reported in Table I:

TABLE I

	Ore/Coal Ratio		Grains per cu. ft.	
December	1.0538	1.0448	2.6	2.6
January	1.0451		2.6	
February	1.0356		2.6	
March	1.0428		2.5	
April	1.0213	1.0301	3.0	3.3
May	1.0390		3.7	
June	1.0255	1.0138	4.2	4.5
July	0.9955		4.8	
August	1.0109		4.9	
September	1.0233		4.2	
October	1.0390	1.0289	3.6	3.3
November	1.0188		2.9	

In Scottish practice the weight of air used per ton of pig iron is about 10 cwt. more than the total weight of all other materials charged into the furnace. So that if much care is taken in selecting, sizing, and conditioning the other materials, it seems only logical to get the air also into the best possible state.

Again, there are so many variable factors in blast-furnace operation, that it is desirable, if possible, to pin down one of the variables. The desirability of constant blast moisture is generally agreed, if such a result can be procured at a reasonable initial and running cost.

Many attempts have been made, and processes suggested, to obtain such a constant blast, either by freezing or by absorption of the moisture chemically with calcium chloride, sulphuric acid, etc. There has been much discussion concerning the merits of these processes, and the criticisms can be summarized under three heads:

1—That the absorption methods have proved impracticable.

2—That freezing is too expensive in maintenance and running costs in comparison with the results obtained.

3—That in all cases the money spent would have been better spent in improving other conditions, such as increasing the blast temperature.

At Wishaw the blast temperature is from 1,450 to 1,500 deg. F. (788 to 816 deg. C.), and it is not possible to raise it without danger to the refractories in the stoves. Although the possible savings from the use of dry blast are not so great at such a blast temperature, it still seemed possible to improve the efficiency of the furnaces if dry blast could be obtained at a moderate cost.

A few years ago the use of silica gel was suggested. This material, which is now made in large quantities and of uniform quality, has wonderful powers of adsorbing water. Its properties were described by Mr. C. B. Miller before the American Institute of Chemical Engineers in Montreal, on June 28, 1920. The main features from the blast furnace point of view are that at atmospheric temperature it can adsorb up to at least 20 per cent of its weight of water from the air with an efficiency of 99/100 per cent, and that by raising the temperature this water can be driven off, leaving the reactivated gel ready for another cycle. It is not advisable to reduce the water content below about 5 per cent. In practice it is desirable to have about 1 lb. of gel for each cubic foot of air to be treated per minute.

A plant to treat 35,000 cu. ft. per minute has been erected at the Wishaw Works of The Glasgow Iron & Steel Company, Ltd., and has been in operation since April 13 of this year.

The plant contains six adsorber units. Each unit consists of a large steel box, in which are placed trays containing the gel in granular form. The bottoms of the trays are perforated, and the latter are so arranged in the box that the air passes through them in parallel. At one end of each box are valves communicating with the atmosphere or with the activating gases. At the other end are similar valves which allow either the air to pass to the blower, or the gases and water vapor to pass to a small exhaust fan which is used for activating. Five units are normally used for adsorption while the other one is being activated. At the atmospheric inlet "Visco" filters are placed to remove the dust which is always found in the atmosphere of an industrial district, and which would, if pulled into the gel beds, tend to clog them and increase the suction (1½ to 2 in. water-gauge) necessary to draw the air through. The heat for activation is provided by the combustion of blast-furnace gas, which has been cleaned in the process of recovering the by-products from the raw coal used in the furnaces. The gas is burnt in a small combustion chamber, and an excess of air is admitted to reduce the activating gases to about 640 deg. F. (338 deg. C.) All the air used for combustion and dilution is also passed through "Visco" filters. The normal period for the activation of one unit is about 1½ hours. During the latter part of this time the gas is turned off and air only is drawn through to cool down the gel and bring it to an efficient condition for adsorption. The valves at the two ends of the boxes are coupled together so that the "reversing" of a unit is done in a single operation. The gas is of about 135 Btu. per cu. ft. and the amount required represents the equivalent of about 7 tons of coal per day.

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*Paper delivered at meeting of British Iron and Steel Institute, Glasgow.

†See Ashton, "Iron and Steel and the Industrial Revolution."

‡Journal of the Iron and Steel Institute, 1904, No. II, pp. 274-300.

§See Industrial Fatigue Research Board Report No. 5, 1920, p. 17.

Between the dehydrating plant and the blower there is an adjustable inlet for atmospheric air, which is used for diluting the dried air up to the moisture figure aimed at. If this were not used it would be difficult to maintain a constant moisture. In cold weather the plant has given a degree of dryness far below anything achieved by Gayley.

It is not easy to give absolutely definite results of the use of dry blast under Scottish conditions. With a number of small furnaces blown at constant pressure from a common main, and making different qualities of iron, many other variables come into the picture. Then again the true blast-furnace gas is so diluted with the "coke-oven" gas formed in the upper part of the furnace that the effect on the CO/CO_2 ratio is difficult to observe. In 1925 the Wishaw Works produced the largest amount of iron recorded in their history, and the fuel consumption was the lowest for many years. It is the latest unbroken year, so that in Table II it has been taken as a standard. In May, June, and July of this year (1927) the dehydrating plant has been in continuous operation, although, being the first of its kind ever built, it is still in the stage of minor adjustments which is common to all new plants.

Moisture in Blast and Atmosphere—The figure for 1925 is taken from the average of the district. The figures for 1927 are the averages of half-hourly spot readings taken at Wishaw.

Output—Since 1925 some slight changes have been made in the lines of three out of the five furnaces now in blast. An analysis of the individual furnace returns shows that not less than 7½ per cent of the increase is apparently due to drier blast.

Total Carbon Used—These figures are taken from the quantities of coal and coke used, and their analyses.

TABLE II

	1925	May 1927	June 1927	July 1927
Moisture in atmosphere. Grains per cu. ft.	3.5	3.08	3.41	4.85
Moisture in blast. Grains per cu. ft.	3.5	1.09	1.20	1.61
Output per furnace per week. Tons	356.5	418.5	400.0	417.6
Percentage increase in output	.....	17.39	12.20	17.14
Total carbon per ton of iron. Lb.	2055	1961	1938	1956
Percentage saving in fuel	.....	4.57	5.69	4.82
Carbon burnt at tuyeres per ton of iron. Lb.	1705	1611	1588	1606
Percentage saving in fuel burnt at tuyeres	.....	5.51	6.86	5.81
Balance of available hearth heat per lb. of carbon burnt at tuyeres (according to Johnson). Btu.	1585	1724	1717	1694
Theoretical saving in carbon burnt at tuyeres (according to Johnson). Per cent	.....	8.06	7.69	6.43

Carbon Burnt at Tuyeres—This is obtained from the total carbon used by deducting 350 lb. per ton of iron as an allowance for solution loss and direct reduction. The actual quantity of 350 lb. is taken from results tabulated by Mr. E. C. Evans from a large number of furnaces using similar ores.

Available Hearth Heat—Wishaw conditions have been assumed, namely, critical temperature 3,000 deg. F. (1,649 deg. C.) and blast temperature 1,450 deg. F. (788 deg. C.), for the purpose of applying Johnson's theory. The balance of heat available per lb. of carbon burnt is shown below:

Grains per cu. ft. of water in blast	Btu. available per lb. of carbon burnt
Nil	1788
1	1729
2	1671
3	1613
4	1557
5	1501
6	1446

The correctness of Johnson's theory is a matter of controversy; certainly his figures seem to agree closely with the actual savings obtained. It will be interesting to see whether future results show such close approximation to his theory.

A point in favor of constant moisture in the blast is the more regular quality of iron produced. This is the experience at Wishaw, but cannot easily be put into figures. The fuel saving, in the case of furnaces on special hematite, must give a small but important reduction in the total phosphorus and sulphur charged into the furnace.

The costs of running such a plant are small. The only moving parts are the hand-operated valves and the motor-driven activating fan, which takes 20 hp. The maintenance costs should also be low.

The financial saving requires to be worked out for each individual case according to local conditions. The amount of fuel saved will depend largely on the blast temperature and the average moisture in the atmosphere; its value on the cost of fuel and the cost of limestone required to flux the ash in the fuel. The further saving in cost per ton will depend on many factors, such as the proportion of the wages cost which represents time wages as distinct from tonnage, the overhead charges, etc. In Scotland if the increase in output exceeds the saving in fuel and there is consequently a bigger coal consumption, overhead charges per ton in the by-product plant will also be reduced, and the net cost of coal will be less.

There does not appear to be any loss of tar with the changed conditions. On the other hand, there is a slight diminution in ammonia recovery, which may be due to the smaller amount of hydrogen in the gases, or may be due to the increased difficulty of cooling the gas, with a bigger coal consumption.

The saving will not be so attractive to those who need their blast-furnaces to act also as gas-producers. Taking everything into account the plant at Wishaw, so far, shows a substantial return on the capital cost.

An interesting question arises as to what is the best degree of dryness in the blast. It seems to be generally agreed that improved furnace operation follows with increased dehydration down to 1 grain per cu. ft. On the other hand, it is known that certain reactions in the furnace are slowed down when the gas is below "calcium chloride" dryness, which represents about 0.1 grain per cu. ft. What happens in between does not seem to be known. Silica gel offers an opportunity of exploring the unknown field between 0.1 and 1.0 grain per cu. ft., and it is hoped at Wishaw at a later date to venture into this region.

For controlling such a dehydrating plant hygrometry becomes important. So far, the readings have been taken with wet and dry bulb thermometers, care being taken to provide sufficient draught and to keep the wick continuously wet with clean water. A recording hygrometer which would give direct readings in grains per cu. ft. would be a great advantage, if the instrument makers could produce one.

The author is indebted to Mr. Edgar C. Evans for the appended historical notes and list of references.

Utilization of Manganiferous Iron Ores

Experimental work, looking toward the utilization of enormous reserves of low-grade manganiferous iron ores in northern Minnesota, being conducted by the Minnesota School of Mines and the United States Bureau of Mines, gives promise of the development of metallurgical processes which will make these ores available for the iron and steel industry. The present supply of domestic ores suitable for the production of ferromanganese, practically indispensable in the manufacture of steel, is not in any way commensurate with the domestic requirements, and it is necessary to import large tonnages of manganese every year. The development of feasible metallurgical processes for the obtaining of ferromanganese from the Minnesota ores would, therefore, be of great national economic importance. The matter is also one of military importance, as imports of the essential manganese might conceivably be cut off in time of war.

In view of the importance of ferromanganese in the steel industry and the total inadequacy of domestic reserves of high-grade ores, the United States Bureau of Mines and the Minnesota School of Mines Experiment Station undertook an investigation looking toward more efficient utilization of manganiferous iron ores. Of the domestic reserves of these ores, it is estimated that about 75 per cent lie in Minnesota. There are two general deposits of ores which have been designated as black (low-phosphorus high-silica) ores and brown (high-phosphorus) ores. The bulk of the ore contains from 0.2 to 0.3 per cent phosphorus, about 10 per cent manganese and about 35 per cent iron. In order to make ferromanganese from these ores it is necessary to change the proportions of manganese, iron, and phosphorus considerably. This can be accomplished by pyrometallurgical processes based upon selective oxidation or upon selective reduction.

For the purpose of conducting experimental work with the Minnesota iron ores, an experimental iron blast furnace, the only one of its kind in the world, was developed. Development of this furnace required the expenditure of several years' time devoted to trials with furnaces of various sizes. By the use of this experimental blast furnace, the investigator is enabled to determine exactly what happens in the furnace under all conditions, something that is not possible with the big commercial blast furnaces.

Because of the great interest which has been shown in the problem being studied, a report of progress so far made has recently been published as Bulletin 12 of the Minnesota School of Mines Experiment Station, University, Minn. The authors of the bulletin are T. L. Joseph, superintendent, North Central Experiment Station, and S. P. Kinney, metallurgist, United States Bureau of Mines.

Tests made with the experimental blast furnace have proved that it is feasible to smelt an ore burden made up entirely of the brown type of manganiferous iron ores, the investigators point out. The high alumina content of the ores, although it must be considered in burdening, does not seriously militate against the smelting of these ores. From the data obtained with the experimental furnace it is possible to predict the fuel consumption and recovery which might be expected with large furnaces and the types of slag which would give the best recoveries. About 150 tons of metal, containing about 12 per cent manganese, 4.5 per cent carbon, 0.25 per cent silicon, 0.55 per cent phosphorus, and below 0.01 per cent sulphur, is available for investigating the next step of the process, which is the separation of iron, manganese, and phosphorus. This will be accomplished by selective oxidation at high temperatures in types of furnace similar to those used in the steel industry today. The products will be low-sulphur steel and a slag low in phosphorus, containing manganese and iron in proportions suitable for the production of ferromanganese. Small scale tests have been made on this part of the investigation and the results form the basis of design of larger furnaces which are now being erected. The results of this work will be reported later.

In addition to proving that the brown ores can be smelted without difficulty and providing metal for investigating the remaining steps of the process, considerable fundamental information has been obtained on the production of ferroalloys in the blast furnace. The important factors discussed are slag basicity, effect of high alumina content, fuel consumption, and recovery.

Copies of Bulletin 12, "Minnesota Manganiferous Iron Ore in Relation to the Iron and Steel Industry," may be obtained from the director, Minnesota School of Mines Experimental Station, University of Minnesota, Minneapolis, Minn.

Coal Handling Plant at Port Covington

Low Percentage of Coal Breakage Is Obtained by the Unloading System Installed for the Western Maryland Railway Company. Dumping Mechanism Novel

THE new coal loading facilities at the Port Covington Coal Pier of the Western Maryland Railway were completed and placed in operation during the early part of October. This equipment was designed and constructed by The Wellman-Seaver-Morgan Company to be used in conjunction with other coal handling machinery on the same pier, consisting of a lifting car dumper and a conveyor loading plant installed by the same company several years ago.

The new equipment includes a W-S-M Revolving Dumper into which cars are introduced by a mule

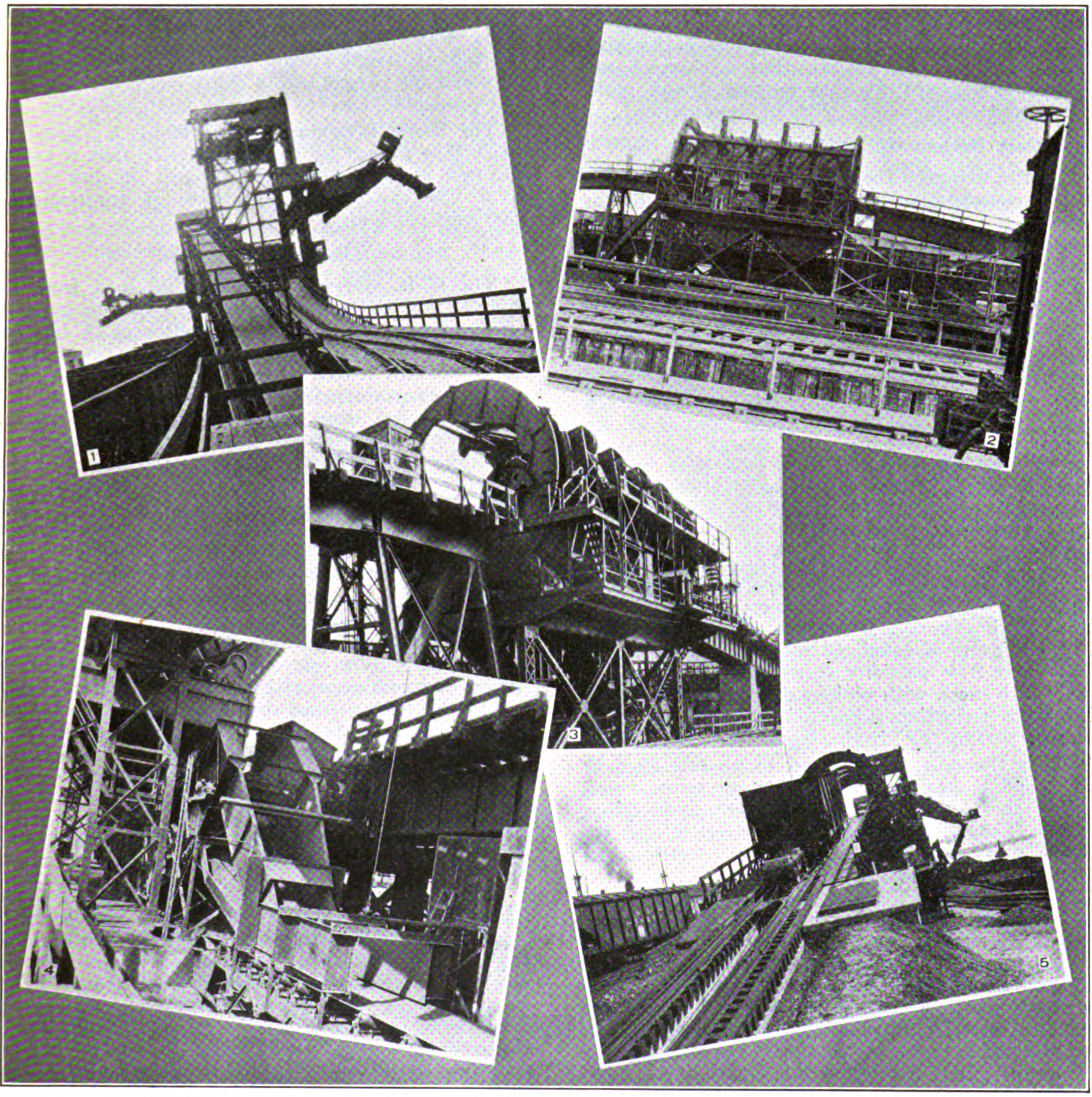

FIG. 1—View looking from the run-off end of the Revolving Car Dumper showing Lifting Car Dumper in back ground and upper end of 60-in. Belt-Conveyor at the left. FIG. 2—Rear view of the Revolving Car Dumper showing receiving hopper below the dumper and Apron Conveyor. FIG. 3—Three-quarter view showing car-riders platform at rear of the Revolving Car Dumper. FIG. 4—Showing Apron Conveyor discharging coal on to the 60-in. belt. FIG. 5—Approach to Revolving Car Dumper showing mule pushing car into cradle of Revolving Dumper.

haulage; a receiving hopper for the coal dumped by the car dumper; an apron feeder for removing coal from the hopper and loading a 60-in. conveyor belt 500 ft. long which in turn delivers the coal to the boat over a conveyor carried on a loading boom. This boom conveyor is part of the original equipment.

This installation has more than doubled the loading capacity of the pier and is chiefly interesting from the fact that it represents the first use of the W-S-M Revolving Car Dumper for loading boats.

The long continued use of this car dumper in coke plants and power stations has demonstrated its simplicity and economy of operation for all operations where material is to be removed from open top cars. The adaption of this machine to boat loading operations is accomplished in such a manner as to reduce breakage far below the ordinary minimum in dumping the coal from cars and the coal thus discharged into the hopper is removed in a slow moving stream, without drop and consequently without degradation.

Cars Pushed Up 15 Per Cent Incline

At Port Covington the road cars from the gravity yard are pushed up a 15 per cent incline into the car dumper as shown. This mule is operated by a haulage and tail rope in the usual manner, both ropes being wound on a drum forming part of the haulage machine.

The drum is geared to the motor by one spur and one herringbone reduction. The 450-hp. mule motor is electrically tied into a 300-kw. generator direct connected to a synchronous motor operating on a 550-v., 3 phase, 25 cycle power supply. The movements of the mule are regulated by automatic control of the generator field, the various slow downs and stops being operated by a traveling nut type limit switch, and a master control switch for operating the starting and stopping switches is located in the operator's cab at the end of the dumper.

The car dumper is of the well known W-S-M Revolving type consisting of a car receiving cradle provided with rings at each end. These rings are surrounded by heavy rails which are supported at each end by two pairs of equalized rollers. Near each end of the cradle it is partially surrounded by gear segments which mesh with pinions driven by spur gears and a worm reduction connected by a flexible coupling to the 100-hp. a.c. driving motor.

This is the only motor used to operate the car dumper and is provided with magnetic control and limit switches for slow down and cut out in either direction. The electrical equipment used in this installation was furnished by the General Electric Company.

The gearing is proportional for a capacity of 35 cars to 40 cars per hour.

Dumping the Car

The car rails in the cradle are mounted on a movable platen which is held in alignment with the approach and runoff rails when the cradle is seated. As the cradle starts to rotate this platen moves sidewise until the side of the car rests against the car blocking. As the cradle continues to rotate four car clamps automatically engage the car and hold it in position while it is inverted to discharge the contents of the car. These clamps descend by gravity to the top of the car, being automatically adjustable to varying heights of cars. After the rotation of the cradle to a predetermined angle the clamps are securely locked in position by counterweighted arms. The counterweights are arranged to travel on inclined guides on the car dumper foundation and on the return cycle the counterweights engage these guides exerting a pull on the clamp lifting chains and raising the clamps.

The dumper is located on an elevated platform which also forms a support for a 75-ton hopper into which the coal is discharged from the cars. This hopper is so located beneath the dumper that the material is restrained from falling when leaving the car but is allowed to fill the hopper gradually as the dumper revolves. The bottom of the hopper is provided with two outlets which are served by a single 54-in. steel apron feeder traveling at 200 ft. per minute. This feeder draws the coal from the hopper without drop in a smooth steady stream which is carried longitudinally and discharged into a chute inclined to give the coal proper velocity to feed the 60-ft. conveyor belt.

The feeder is operated by an 80-hp. a.c. motor to which it is geared by change gears so that it can be operated at high speed (200 f.p.m.) or slow at 100 f.p.m. The capacity at high speed is approximately 2200 tons per hour.

Distribution of Coal

The 60-ft. conveyor receiving its load from the chute at the head end of the feeder, is carried by roller bearing troughing idlers up an incline of 14 deg. and a short horizontal run, to the loading tower about 500 ft. distant where it discharges direct to a 54-in. apron conveyor carried by a boom on the loading tower, the coal being discharged through a telescope chute suspended from the outer end of the boom and extending into the boat. The 60-ft. conveyor is driven by tandem pulleys directly geared to a 250-hp. a.c. motor. This mechanism is also provided with change speed gears so that the speed may be varied from 650 f.p.m. maximum to 350 ft. minimum. A gravity take-up is provided adjacent to the tandem drive pulleys.

Observation of the operation of this plant gives ample basis for the conclusion that there is practically no breakage of coal. Contrary to the usual contention that transfer from one carrying medium to another causes degradation, coal is transferred from the hopper to the feeder, from the feeder to the 60-in. conveyor, and from this to the boom conveyor with practically no agitation and a very noticeable absence of dust which is always present when breakage occurs.

Rust Engineering Company Reorganizes Furnace Department

Mr. A. L. Culbertson, vice president and assistant manager; Mr. O. D. Rice, engineer in charge of design, service and operation; Mr. D. W. Ewalt, sales engineer and Mr. J. W. Barker, construction engineer, all of the Chapman-Stein Furnace Company of Mount Vernon, Ohio, have recently resigned their former connections and are now affiliated with The Rust Engineering Company of Pittsburgh, Pa.

Complete reorganization of the furnace department of The Rust Engineering Company has been made with this division now under the direction of the above men. These men have been engaged in furnace design, sales and construction for the past eight years with Chapman-Stein.

Growth of American Steel Industry*

A Review of the Economic and Social Factors Which Contributed to the Expansion and Development of the Steel Trade. Statistics Illustrate Progress

By THEODORE W. ROBINSON†

As late as 1860 manufacturing in the United States was chiefly confined to comparatively small units located in the communities that fringed the Atlantic seaboard. Transportation was slow and costly, and distribution was largely for local consumption. Industrial ownership lay in the individual, partnership, or small corporation, and there was close contact between men and management. Wages and output were low, luxuries few and far between, and standards of living were relatively simple.

It is clear that the underlying reason for the remarkable progress made in the 25 years following the close of the Civil War in 1865 was the introduction of the Bessemer process. No single industrial invention ever had such a vital and far-reaching effect on the commercial and social destiny of any nation as this new steel-making process had upon the United States. The first Bessemer ingot made in the New World was produced at an experimental plant at Wyandotte, Mich., in 1864, but steel did not begin to be an important factor in the replacement of iron till 10 or 15 years later.

The Twentieth Century

The twentieth century opened auspiciously for the United States amidst long-deferred prosperity. The rapid progress made in the period just reviewed was founded upon new processes and new methods, distinctly technical in their character, which followed the introduction of the manufacture of steel.

Production of Iron and Steel

In 1901 the United States with its output, in round numbers, of 13,500,000 tons of ingots and castings, produced 44 per cent of the world's steel. This by 1926 had expanded to more than 51 per cent of the world's total, with its production of over 48,000,000 tons of steel. Whereas 25 years ago the steel ingots made in the United States consisted of more than 66 per cent acid Bessemer, nearly 84 per cent of the steel now produced is of basic open-hearth. This, in brief, tells the nation's accomplishment for the first quarter of the century, and records the large replacement of the Bessemer converter by the open-hearth furnace, a change superinduced by the changing character of the country's ore reserve.

The production records of the past 25 years at the South Chicago Works of the Illinois Steel Company furnish a concrete illustration of the effect of such advances. These works represented in 1901, as they do now, the best modern practice. The average daily output of each of the South Chicago blast-furnaces increased from 318 tons in 1901 to 679 tons in 1926. During this period the acid Bessemer department increased its production from 70,000 tons to 100,000 tons per month, and the basic open-hearth furnaces increased from an average output per furnace of 586 tons per week to 1379 tons per week. The South Chicago rail mill had an average capacity of 60,000 tons per month in 1901, while the Gary rail mill, by which it has been replaced in the rolling of rails, has a capacity of 100,000 tons per month. These figures reasonably illustrate the unit advance in physical production which has taken place in the iron and steel industry in the United States.

A still more important development in American practice is the increased per capita output of the average iron and steel workman. This is strikingly illustrated by the following South Chicago records:

Illinois Steel Company (South Works)
Tons produced per Man-Hour

	1902	1926	Increased Percentage
Ore unloading	2.087	16.835	706.7
Blast-furnaces	0.185	0.698	277.3
Bessemer ingots	0.421	0.841	99.8
All open-hearth ingots	0.252	0.418	66.0
Rail mill (South Works, 1902) Rail mill (Gary Works, 1926)	0.189	0.416	120.1

This table shows that the average man in a modern iron and steel plant is producing from 1½ to 8 times as much as he did 25 years ago. If translated into yearly volume, these figures indicate that at South Chicago the average workman has increased his ore-handling capacity since 1902 from 6000 to 48,000 tons; his pig iron output from 675 to 2405 tons; his Bessemer ingot production from 1761 to 3730 tons; his open-hearth ingot production from 1049 to 1842 tons; and his rolling capacity from 603 to 1240 tons of rails.

That this accomplishment is fairly typical of the changes that have taken place in like branches of the industry for the country as a whole is supported by data lately published by the United States Department of Labor, which shows an average increase in worker productivity upon a man-hour basis of 165 per cent from 1899 to 1926 for crude iron and steel products.

Power Installation

The manufacturing productivity of any nation can be roughly measured by the amount of its mechanical energy, and the marked growth of power application in the United States has made possible its expansion and prosperity. From 1899 to 1925 the country's primary horse-power more than trebled, and as a result of this increase there is now 4¼ hp. at the service of every manufacturing wage-earner.

On the conventional assumption that 1 hp. is equal to the unassisted physical effort of 10 men, the average capacity of the individual worker in the United States is more than 40 times what it would be if unaided by mechanical energy.

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*Abstracts from paper delivered at meeting of the Iron and Steel Institute of London, at Glasgow, September, 1927.

†Vice president, Illinois Steel Company, Chicago.

The manufacture of iron and steel has more than kept pace in power installation with the progress made in general industry. During the last 25 years its use of power has increased nearly fourfold, and to each of its workmen there is now given the energy of over 16 hp.

The extent to which power usage has been amplified and the electrification of plant increased is strikingly exemplified by the Gary Works of the Illinois Steel Company. A short generation ago the reciprocating steam-engine was the principal prime mover in both primary and secondary units. At Gary the production and utilization of power is dependent upon the blast-furnace gas-engine, steam-turbine, electric generator, and motor. Here 11,716 men were able in 1926 to turn out more than 2½ million tons of finished product, because behind each of them was the electrical energy of nearly 20 hp.

Wages and Their Relation to Living Cost

It is but natural to ask whether or not the increase in worker productivity, in which power usage is such an important factor, has been followed by an increase in "real wages." Wages and earnings in the Chicago district may be considered as typical of those existing elsewhere in the iron and steel industry of the country. In 1901 the daily wage was based on 15 cents per hour, and the average yearly earnings of all employes of the South Chicago Works for that year was $825. By 1926 the hourly rate had risen to 44 cents, and the average yearly earnings to $1870, an increase of 127 per cent, or more than double the amount of earnings received before. With this increase in earnings went also a reduction of nearly 18 per cent in the hours the men were required to work. Prior to 1922 the iron and steel industry had been operated almost universally on the basis of 12 hours for continuous operations, and 10 hours for non-continuous operations. In that year the present 8 and 10-hr. day working schedule was adopted, and several years earlier the seven-day week had been replaced by the six-day week.

Increase in Steel Capacity

Due to the exigencies and stimulation of the war, the ingot capacity of the United States increased slightly over 15 million tons for the six years 1915 to 1920 inclusive, or at the rate of approximately 2½ million tons per year.

The end of the war left the country with excess plant development, and for six years subsequent to 1920 the total ingot capacity increased less than 3½ million tons, or at the approximate rate of half a million tons per year. The theoretical steel ingot capacity of the nation is today, in round numbers, 58 million tons. While during the war no expense was spared to enlarge the country's steel capacity, investment during the last six years has been made with special reference to the reduction of costs, diversification of product, and the betterment of quality instead of increased production.

Management

Just as the exigencies of expanding business 50 years ago resulted in the small corporation taking the place of individual ownership and control, so their resulting economies brought into existence the larger corporations of today. In the last two decades of the nineteenth century there was not always a proper appreciation of the difference in power and responsibility between large and small aggregations of capital. Management was then apt to measure responsibility and success by the profits it made rather than by the methods it employed. The rights of the public, the competitor, and employe were ofttimes neglected; monopoly was not always discountenanced; labor was sometimes exploited; prices were apt to fluctuate from exorbitant heights in good times to ruinously low figures in bad times; competition was frequently destructive, and business ethics too often failed to square with the golden rule.

Such principles and methods of doing business fell into disrepute years ago. Management learned that the difference between monopoly and unreasoning competition is the difference between ephemeral success to the few and industrial suicide by the many, that the exorbitant profits of a peak demand were offset by the losses of succeeding reaction, and that stability in price helps stability in operation.

Labor

Because of the large increase in the number of small investors the line of demarcation between so-called labor and capital is rapidly lessening. There is a better appreciation today that the nation's capital is principally the savings of labor's thrift and is largely owned by labor itself. With the dissemination of this truth has also gone a better realization that in American industry the labor of the office and counting-room is in the same economic category as the labor of the mill or field, and that the officials of management are just as truly employes of the corporation which hires them as the men working under their direction.

The composite American workman is of a high order of intelligence, peculiarly free from traditional bias and restraint, and welcomes as a rule mechanical assistance for the increasing of his output because of its greater attendant earnings. He is especially jealous of his right to freedom of action, is quick to resent unjust treatment, and does not hesitate to change the character or place of his employment if dissatisfied or if better opportunity presents. He resents political and organized domination, and prefers his own negotiations to bargaining by representatives.

In 1906 the United States Steel Corporation inaugurated a campaign of safety, sanitation, and welfare which has ever since been vigorously pursued. Tonnage and costs became no longer the sine qua non of achievement, and the safety and welfare of the worker is a vital consideration in mill operations.

Accident prevention has naturally been most prominently stressed. The safeguarding of machinery starts with the drafting board in all construction, and is diligently pursued thereafter as experience permits. Education and organization of men into safety committees plays an important part, and that expense is not allowed to interfere with the desired object is indicated by the expenditure by the United States Steel Corporation last year of 1¾ million dollars in safety work.

As a result of such intensified effort extraordinary reduction in the accident rate has been achieved. Among the quarter of a million men employed by the United States Steel Corporation in 1926 the rate of disabling accidents was 3.26 per cent as compared with 20.57 per cent in 1912, or a reduction of 84.15 per cent of the former rate. That means that in the company 365,277 men have been saved from disabling injuries since 1912, as measured by the sum of the reduction in accidents each year.

Consumption and Markets

At the beginning of the century the United States, with a population of 76,000,000 people, produced 9½ million tons of finished steel, while in 1926, with a population of 117,000,000, this output had risen to 35½ million tons. In other words, each inhabitant as an average used 739 lb. of finished steel in 1926 as compared with 279 lb. in 1900, or over 2½ times more now than formerly. This expansion is essentially due to increased domestic demand, and has been but little influenced by the small percentage of growth in the country's foreign trade. The following statistics show how small this change has been. The iron and steel imports and exports of the United States, in round numbers, were respectively 200,000 tons and 1,000,000 tons in 1900 as compared with imports of 1,000,000 tons and exports of 2,000,000 tons in 1926.

The increasing ramifications of steel's new uses are continually making for widening markets. With greater diversification of product has come an insistent demand for quality, so that today trade requirements are infinitely more severe than in former years. The comparatively rapid growth of alloy steels and the increasing call for electrical refining is a result of this demand, and such special steels are an important and growing factor in the economic progress of the country. The change in the character of the demand is illustrated by the item of rails. At the beginning of the century the production of rails absorbed 25 per cent of the country's entire steel output. Last year, although the rail tonnage was half again as large as it was 25 years ago, it represented only nine per cent of the country's steel production.

In the new demand for steel the most important development is the expansion of the automotive industry, which last year took 15 per cent of the nation's output.

Summary

The economic progress or retrogression of any nation depends upon the expansion or curtailment of the individual production of its workers, and the secret of America's well-being lies in its unrivaled per capita output.

At the back of all accomplishment, however, is human effort, and the installation of power and the wealth of material resource will be but abortive aids unless utilized and directed by the hand of able and willing labor.

The character of any people depends upon their education and environment, and their material welfare can only be assured if founded upon sound economic methods. The irrevocable law of supply and demand is nothing but human nature reduced to a formula, and composite human nature is unchangeable in its primary instincts in spite of civilization's veneer.

Consumption is vitally affected by costs of production, but for management to lower costs by reducing wages if they are reasonable is just as shortsighted as for labor to try to improve its condition by restricting its output. Both, if continued, must inevitably lead to lower standards of living.

High wages and high dividends can only come from high production, and high production will be better assured if labor is not only paid to produce but also is paid by what they produce. Tonnage rates, piece-work, and bonuses for favorable performance spell high earnings when justly formulated, and American production owes much to this enlightened method of labor remuneration.

Prosperity to continue must be based upon a thriving public, contented labor, and adequately remunerated capital. If any one of this essential trinity becomes unbalanced the wheels of industry will slow down and prosperity disappear.

As a prophet may not be without honor, save in his own country, the author ventures the prediction that as war has given way to peace, so will ignorance give way to economic enlightenment, and that in the new spirit of industrial co-operation there will be found both greater prosperity and a better understanding between the nations of the earth.

Open Hearth Engineers Meet

The Open Hearth Committee, an organization sponsored by the American Institute of Mining and Metallurgical Engineers, held its semi-annual meeting at the Hotel Statler, Detroit, from November 2 to November 4. The topics presented for consideration covered many phases of open hearth practice, such as: What is considered a good yield on 68 to 72 per cent hot metal and on 40 to 45 per cent pig iron charge; can dissolved iron or manganese oxide be detected in pig iron, and what effect have they on the quality of steel made from pig iron containing large quantities?; cause and elimination of ferrite banding in low-carbon steels; relationship of slag volume to speed of furnace operation and to quality of steel; percentage and analysis of pig iron for greatest furnace speed; how and when to take final preliminary tests, and how to cool high-carbon steel samples; method of setting and maintaining open hearth bottoms; difference in rebuilding costs for coke-oven gas, liquid fuel and producer gas furnaces; advantages, if any, to be derived from deepening checker chambers; number of checker brick salvaged on a general repair and question of how they may be cleaned and whether cleaning is advisable; practice with regard to air spaces between slag pocket walls and regenerators, and to what extent slag pockets are insulated; temperature at rear peep hole in air checkers when heat is tapped; fuel practice in B.t.u. per ton, including fuel for heating up and for ladle and spout and what percentage of loss is figured on coal practice due to producer operation; refractory practice, covering raw versus burnt dolomite, domestic versus foreign magnesite and use of chrome ore for patching jambs and tap holes; relationship of mold analysis to mold life; discussion of furnace construction questionnaire; problems for the spring meeting of 1928.

Coke Ovens to be Heated with Blast Furnace Gas

Erection of a by-product coke plant to be built for the Youngstown Sheet & Tube Company, at its Indiana Harbor, Ind., plant has been commenced by the Koppers Construction Company, Pittsburgh. The plant will consist of 70 Becker-type ovens, a by-product installation, coal and coke handling systems and a gas cleaning plant. The ovens will have an annual carbonizing capacity of about 740,000 tons of coal. The installation is of particular interest inasmuch as the ovens will be the first in America to be fired with blast furnace gas.

The Characteristics of Modern Stokers*

Definitions of Stoker Types. Requirements Met by Traveling-Grate and Multiple-Retort Underfeed Types. Air Control and Duplex Firing of Underfeed Stokers

By F. H. DANIELS†

BEFORE going into the subject of the characteristics of modern stokers, it will be well first to establish some definitions in order that it may be understood just what is being referred to. The Stoker Manufacturers Association have adopted a certain nomenclature in reference to the classification of the different types of stokers. These definitions are as follows:

Definitions

1—*Grate.* A grate is a metallic structure designed to support fuel, and so made that air for combustion can pass through the grate to the fuel.

2—*Mechanical Stoker.* A mechanical stoker is a device consisting of a mechanically operated feeding mechanism and a grate, and is used for the purpose of feeding solid fuel into a furnace, admitting air to the fuel for the purpose of combustion, and providing a means for removal or discharge of refuse.

3—*Overfeed Stoker.* An overfeed stoker is a stoker where fuel is fed on to grates above the point of air admission. Overfed stokers are divided into three classes, as follows:

a—A front-feed inclined-grate stoker is an overfeed stoker where fuel is fed from the front on to a grate inclined downward toward the rear of the stoker.

b—A double-inclined side-feed stoker is an overfeed stoker where the fuel is fed from both sides on to grates inclined downward toward the center line of the stoker.

c—A chain or traveling-grate stoker is an overfeed stoker where the fuel is fed to the stoker from the front on to a moving grate forming an endless chain.

4—*Underfeed Stoker. An* underfeed stoker is a stoker where the fuel is introduced at a level below the point of air admission.

5—*Multiple-Retort Stoker.* A multiple-retort stoker is an underfeed stoker consisting of a number of troughs or retorts placed side by side with a coal-feeding mechanism at the front end of the retorts and provided with ash-disposal means located at the rear end of the stoker.

As a general rule, the tendency of the times is undoubtedly toward larger power-plant units of all kinds. This is brought about by economic reasons, in accordance with the old, familiar law of the squares and the cubes. The volume, and consequently the capacity, goes up as the cube of the lineal dimensions, while the surface, and thus the radiation and other losses, increases only as the square of these same lineal dimensions. In other words, the larger the boiler, the more efficient it should be. There is also a very noticeable demand for higher and higher boiler ratings. In this paper the author proposes to confine his remarks to the only two types of stokers which are suitable for the larger modern boilers operated at high capacity. These two types are the chain or traveling-grate stoker and the multiple-retort underfeed stoker. In order to meet the requirements for high capacity, both types must of course be provided with forced draft.

Characteristics Demanded of Modern Stokers

As boilers get larger and larger the amount of floor area available under the boiler becomes less and less per unit of boiler capacity. In other words, a 1000-hp. boiler will not have twice the floor area under it that a boiler rated at 500 hp. has. The same high overload capacity is desired from a large boiler as from a small one. This means that in most cases the stoker must be so designed that it can be built in lengths equal to the maximum space which is available, and there must be no limit whatever upon the width of the stoker, because the entire space under the boiler must in most cases be utilized for fuel-burning area. The growing use of water walls in the furnace whereby much of the water-heating surface is located on the vertical walls instead of in the boiler proper still further intensifies reduction in the floor area available per unit of boiler capacity, and at present the stoker manufacturer is many times at a loss where to put sufficient coal-burning area under the boiler in order to get the capacities wanted. The first characteristic of modern stokers, therefore, must be that there must be no limitation on size. It must be possible to build the stoker as large as the floor area that is available, and, if the floor area is limited, the stoker must be capable of high rates of coal burning.

The second characteristic is that the stoker must be able to meet sudden overload demands with no appreciable drop in steam pressure.

The third characteristic is that the stoker must be provided with an automatic and continuous ash-discharge mechanism.

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*Paper presented at First National Meeting of the A.S.M.E. Fuels Division, St. Louis, October 12, 1927.

†President, Riley Stoker Corporation, Worcester, Mass.

The fourth characteristic is that the stoker must be capable of being operated with preheated air. In order to prevent too much air at the rear end of the stoker, the pressure of air under each section of the stoker from front to rear must be under the control of the operator. This was formerly not so necessary with short stokers, but it has now become an important feature.

In addition to these characteristics which should be possessed by the stoker, it is also essential that above the stoker there should be means provided for preventing stratification of gases, i.e., the richer gases coming off at the front end of the stoker should be forced to mix with the leaner gases coming off at the rear end so as to insure uniform quality of gas going to the boiler heating surface. Taking up the two types of stokers, it will be shown how they meet the requirements that have just been set forth.

Traveling or Chain-Grate Stokers

The traveling or chain-grate stoker has been built in widths up to 24 ft. and in lengths up to 23 ft. of fuel-supporting area. The length referred to is the distance from the inside of the coal gate to the point where the grate changes its shape from a plane to a curved surface at the rear end. In other words, the area is only actual fuel-supporting area where combustion is taking place. Multiplying these two dimensions gives a maximum fuel-burning area of 552 sq. ft. Figuring 40 lb. per sq. ft. gives an economical coal-burning rate of 22,000 lb. per hour, which would correspond to a 2500-hp. boiler at about 200 per cent of rating. The same stoker would have an easy peak capacity equal to 250 per cent of rating on the same 2500-hp. boiler, or about 200,000 lbs. of steam per hour. This stoker requires as a necessary part of the furnace design a front arch, and consequently the space under the boiler imposes no limit on the length of the stoker since the stoker may extend out in front of the boiler without forcing a detrimental furnace design. It should be noted that it is possible to arrange two chain-grate stokers back to back in a single furnace, thus doubling the possible maximum capacity or giving an evaporation of about 400,000 lb. of steam.

While the traveling-grate stoker gives a quick response to overload demands, it is not quite as good for this purpose as the under-feed. The reason for this is easily seen because the depth of fuel bed on the traveling grate is only about 4 to 8 in. as compared with 1 ft. to 2 ft. 6 in. on the under-feed. Consequently there is less of a reservoir of coal in the furnace from which to draw heat when the demand for steam comes. Fig. 1 shows what can be accomplished in this respect with a traveling-grate stoker.

In regard to ash discharge, there could be nothing more continuous or automatic than the manner in which the traveling-grate gets rid of its ash refuse. The very design of the grate in the form of an endless-belt conveyor is ideal for ash dumping.

Preheated air at a temperature of from 400 to 500 deg. F. has been used successfully on traveling-grate stokers. The relatively thin fuel bed on the traveling-grate stoker, ranging from perhaps 4 to 8 in., necessitates the use of a number of compartments from front to rear, the air pressure in each compartment being controllable at will. The natural-draft chain-grate stoker is of course not suitable for high capacities, and merely applying forced draft to a natural-draft stoker never worked out successfully due to the tremendous amount of excess air which was forced up through the rear end of the stoker where the fuel was practically burned out and the fuel bed porous and open. The idea of putting in compartments on the traveling or chain-grate stoker and controlling the air in each compartment in accordance with the fuel-bed conditions made the chain-grate stoker a suitable unit for use under high-capacity conditions. With the chain-grate stoker the recent addition of the rear arch gives proper mixing of the gases in the furnace at the throat, and prevents the lean gases from reaching the boiler tubes before they have had a chance to meet the rich gases from the front arch. This insures that combustion will be more nearly completed in the furnace, so that secondary combustion in the space between the boiler tubes is either completely eliminated or greatly reduced. This arrangement adds much to the economy of operation. Fig. 2 shows an ideal furnace arrangement of front and rear arch.

Multiple-Retort Under-Feed Stokers

The multiple-retort under-feed stoker has been built in lengths up to 20 ft. This is generally about all the space which is available under a boiler, and corresponds roughly to a horizontal water-tube boiler with 22-ft. tubes. The under-feed stoker has been built in widths up to 32 ft. On the question of lengths, two under-feed stokers of course can be put back to back with dump in the middle, giving the maximum possible depth of 40 ft. There is no reason why stokers of this type cannot be built 40 ft. wide also. Taking the above dimensions, 32 ft. wide by 40 ft. deep, using two stokers back to back, gives a coal-burning area of 1,280 sq. ft. which gives an economical coal-burning rate of 60,000 lb. per hour, equivalent to 15,000 hp., or an evaporation of about 450,000 lb. per hour. The corresponding easy peak capacity would be about 600,000 lb. of steam per hour.

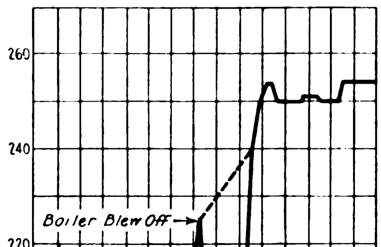

FIG. 1—Quick response to overload demand obtained with a traveling-grate stoker.

Arches are not necessary or desirable for multiple-retort under-feed stokers. In fact, their use is detrimental. This means that the floor space directly under the boiler is about all that can be used for coal-burning area. In many cases with large high-capacity boilers it is becoming difficult to get in sufficient coal-burning area to suit the load demands, especially when water walls are used. The large amount of coal in the fuel bed of an under-feed stoker insures almost instantaneous response to sudden load increases. Fig. 3 shows what has been done in this respect. There is practically no limit to the speed at which load may be increased, provided a sufficiently high air pressure is available under the stoker. The fuel bed in an under-feed stoker contains at all times an amount of coal equal to about that which could be fed in by the stoker during one hour. This gives an idea of the amount of heat that is stored up in the fuel bed waiting only increased air supply to be released.

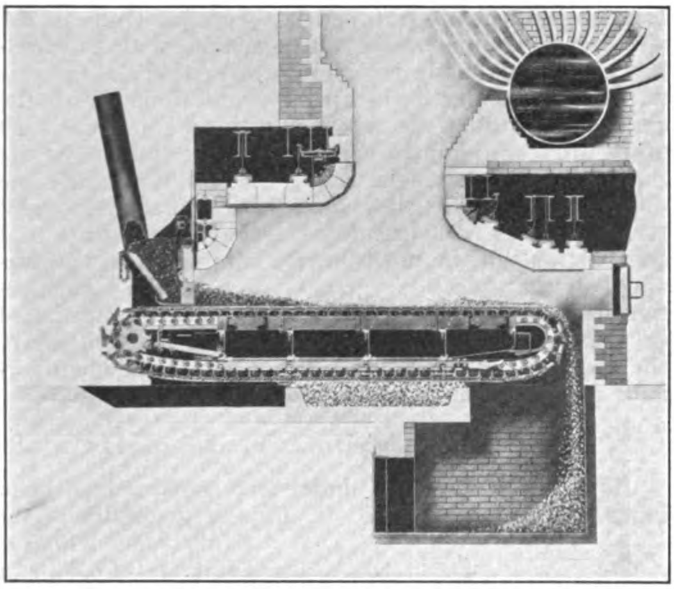

FIG. 2—Ideal arrangement of front and rear arch in chain-grate-stoker furnace.

The successful development of the clinker grinder for the under-feed stoker insured easy automatic ash removal and at the same time it cuts in two the ashpit losses due to unburned carbon. These ashpit losses are now so small that it is a question whether it would be worth while to add anything more to the cost of the stoker with a view of reducing them still further.

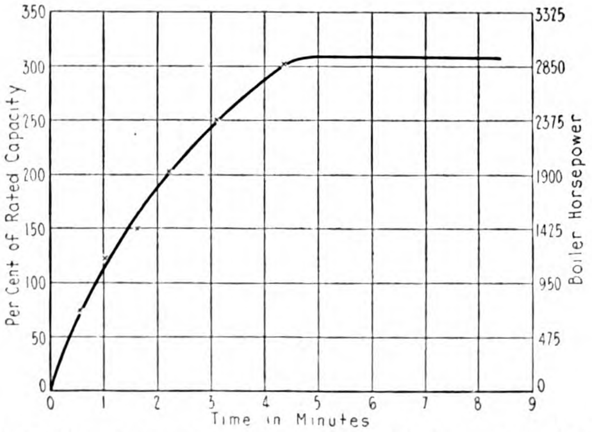

FIG. 3—Showing rapid response of multiple-retort underfeed stoker to sudden load increase.

On preheated air, the multiple-retort, under-feed stoker has amply demonstrated its ability to withstand temperatures of from 400 to 500 deg. F.

Air Control Along Length of Retort

It has long been customary to supply a separate air conrtol to the rear end or overfeed section of under-feed stokers, but the question of controlling the air supply along the length of the retort is just beginning to receive active study and embodiment in practice. The thickness of fuel bed ranges from 1 ft. to 2 ft. 6 in., and consequently there is not as much necessity of air control from front to rear as is the case with the traveling or chain-grate stoker. It is believed, however, that control of air front to rear on the under-feed stoker would give good returns, and much work is now being done along these lines.

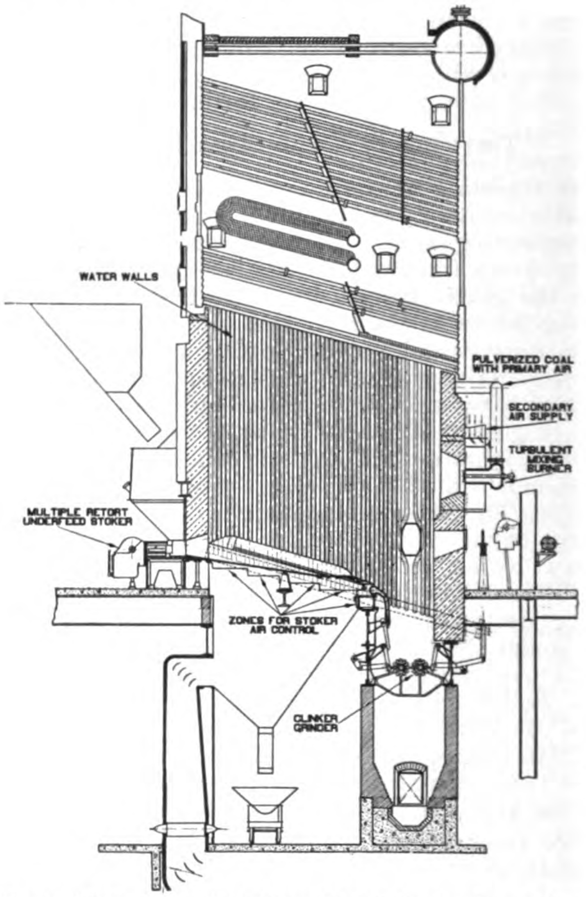
WATER WALLS
PULVERIZED COAL WITH PRIMARY AIR
SECONDARY AIR SUPPLY
TURBULENT MIXING BURNER
MULTIPLE RETORT UNDERFEED STOKER
ZONES FOR STOKER AIR CONTROL
CLINKER GRINDER

FIG. 4—Showing installation of turbulent mixing burner in rear wall of multiple-retort underfeed-stoker furnace.

With the long under-feed stokers, especially those with clinker grinders, there is some stratification of gases in the furnace. In an attempt to burn out the last bit of combustible in the ash there is always a tendency to get an excess of air up from the rear end of the stoker. This gives the lean gas. Arches as used on the traveling-grate stoker are impossible for the under-feed stoker, so some other method of mixing must be used to insure the same beneficial results that the rear arch gives on chain-grate stokers. The author suggests that a small unit pulverizer be installed in connection with multiple-retort underfeed stokers, using a turbulent mixing burner installed in the rear wall of the furnace somewhat like the arrangement shown in Fig. 4. This would accomplish a number of desirable results. Pulverized coal has one disadvantage in that it is difficult to maintain ignition at extremely low ratings. The stoker, however, with suitable drive mechanism and proper controls can be operated at any rating from a bank up to high capacities. A boiler installation with the duplex firing as suggested would be able to operate at low ratings down to a bank. The unit pulverizer would only be put into service to meet the peak-load demands. The pulverized-coal burner in the rear wall would set up a turbulence in the furnace and would insure the lean gases coming off from the rear end of the stoker getting mixed with the richer gases from the front end. There would be no loss due to stratification.

In underfeed-stoker operation it is possible to obtain very low carbon in the ash by putting more air than usual through the fuel bed at the rear of the stoker. This method of course means low average CO_2 in the furnace and much leaner gas at the back of the furnace. By using a slight deficiency of air with the pulverized-coal burner the oxygen in the lean gas can be utilized without decreasing the overall economy of operation. The stoker itself with its clinker grinder is well adapted to automatically dispose of the pulverized-coal ash which drops down on the fuel bed. One of the serious problems with pulverized-coal burning is what to do with the ash that collects on the bottom of the furnace. It is in the form of finely divided particles which blow away when there is the slightest wind, so it is difficult to use it for fill. It is not easy to wet it uniformly so that it can be handled without making a dusty job. With the proposed duplex firing the small amount of powdered-coal-ash dust would be so mixed in with the more plastic stoker ash and clinker as to not affect the ready sale of the resulting product. There are many successful underfeed-stoker installations where blast-furnace gas is used as an auxiliary fuel fired in the furnace over the stoker. There would be very little possibility of damage to the stoker parts on account of the thick fuel bed used on underfeed stokers, and by leaving a bed of ashes on the stoker it would still be possible in an emergency to run the pulverized-coal equipment without operating the stoker, allowing a bed of ash to protect the grate surface. This duplex-firing scheme offers a solution in cases where there is not sufficient floor area available to give coal-burning capacity equal to the boiler ratings desired. The heat of the pulverized-fuel flame above the stoker fuel bed would insure better burning out of the stoker ash. It seems as though it would be particularly adaptable for central-station use where the maximum output is desired during the peak hours. Large furnace volumes are now regular practice for high-capacity stoker work and no additional space would be needed since this space would merely be better utilized due to the better mixing resulting from the addition of the turbulent powdered-coal burner. For very high capacities water walls would be required, but these are being used now for many stoker installations. The water walls would also reduce the danger of clinkering due to coal of low ash-fusing temperature, and a sufficient amount of water-wall surface must be used to hold furnace temperatures down to a reasonable figure considering the quality of the coal to be used. The only increase in cost would be the price of the unit pulverizer and burner, and this would easily justify itself by reason of the increased capacity obtained from the boiler during the peak hours. The tendency of the stoker to show a large drop in efficiency at high capacity would be largely offset and it would not be necessary to sacrifice economy to get capacity.

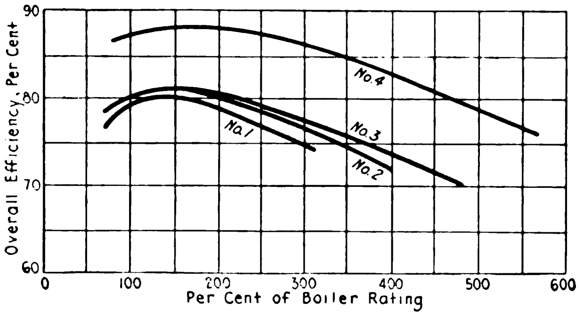

FIG. 5—Increased efficiency and capacity obtainable by applying duplex firing of pulverized coal to a clinker-grinder stoker.

Curve 1—Dump-plate stoker. Curve 2—Clinker-grinder stoker.
Curve 3—Duplex firing with clinker-grinder stoker.
Curve 4—Duplex firing with clinker-grinder stoker and preheated air.

Fig. 5 shows in a general way what might be accomplished in the way of increased efficiency and capacity by applying duplex firing of pulverized coal to a clinker-grinder stoker both with and without preheated air.

Coming Power Show

In scope, size, value of exhibits, attendance and influence on industry the coming National Exposition of Power and Mechanical Engineering, will be an important factor in the future development of industry. Over 100,000 visited the 1926 show and the 1927 event is sure to attract a much larger crowd. Compare it with the first show in 1922 when about 150 exhibits occupied only one floor and the attendance was only about 20,000. The first show was a success, however, and when the second one filled two floors and attracted a larger attendance, the "Power Show," as it was known, became an established fact as an annual clearing house for the newest and best in power machinery. In the past three years the exposition has broadened in scope and it is now much more than a powershow. It may rightly be called a "Mechanical Show" as it includes mechanical equipment usable in many industries and the executive and engineers in those industries attend it and profit greatly. All of the 100,000 who passed the gates at the last mechanical show were not potential buyers, but most of them carried away a new conception of machinery or new ideas which they could use and the show was a worthwhile thing to all of them.

In the planning and conduct of the exposition, the management is aided by an advisory committee consisting of Messrs. I. E. Moultrop, chairman, Edison Electric Illuminating Company of Boston; Homer Addams, past president A.S.H.V.E.; E. Paul Anderson, president, A.S.H.V.E.; N. E. Carle, vice president and general manager, Public Service Production Company; Willis H. Carrier, president, A.S.R.E.; Fred Felderman, past national president, N.A.S.E.; C. F. Hirshfeld, chief, research department, Detroit Edison Company; O. P. Hood, chief mechanical engineer, U. S. Bureau of Mines; John A. Hunter, chairman power division A.S.M.E.; E. B. Katte, chief engineer electrical traction, N.Y.C.R.R.; R. T. Kent, chairman, professional divisions committee A.S.M.E.; John H. Lawrence, Thomas E. Murray, Inc.; Fred R. Low, past president A.S.M.E.; David Moffat Myers, construction engineer; R. F. Pack, president N.E.L.A.; Calvin W. Rice, secretary, A.S.M.E.; Charles M. Schwab, president A.S.M.E. The managers of the exposition are Fred W. Payne and Charles F. Roth.

Steel Mill Boiler Plant of Latest Design*

In the Plant Here Described the Boilers Are Fired with Powdered Coal Delivered by Unit Type Pulverizers. One of the Most Recent Installations

By D. L. MEKEEL†

THE ideal condition for a steel mill is to produce sufficient power from the blast furnaces to completely process the steel products. We are all endeavoring to approximate this goal as nearly as may be practicable; but in locations where coal is cheap we naturally are not justified, on account of the required investment, to reach as far in this direction as in the dearer coal markets. Coupled with this condition, we have many works which carry on to a more highly finished product in the same plant, calling for additional power for the processing.

In view of the above conditions, there are many places where power will be produced from coal-fired steam for many years to come, and it is one of these with which we have to deal.

Material advances have been made in the art of steam production during the past few years making available material operating savings in new plants as compared with the majority of plants now in steel mill operation, many of which were built piece-meal; and as well as not being up to modern standards, are not co-ordinated within themselves to produce good operating efficiency.

While the last word has not been said in steam generation, it is unlikely that very material farther strides will be made affecting over-all economies of boiler plants, capital charges included, for some time to come, so the investor in a proper boiler plant today puts himself in a comfortable position.

The Jones & Laughlin Steel Corporation, due to its cheap and convenient coal supply and the production of highly finished products in the same plants as the primary operations, is one of the steel makers who will doubtless find it profitable to produce a percentage of their power from coal-fired steam for a long time.

The boiler house which we will discuss does not, on account of cheap fuel, contain all the devices to capture and hold the last Btu., but we believe goes as far as is economical from a financial standpoint under the conditions, and possesses a reliability, simplicity and flexibility well adapted to carrying satisfactorily a steel mill load. These qualities are of primary importance.

In this case also the speed of execution of the engineering and construction, as well as some features of the foundation construction, are of especial interest.

At the South Mills of the Aliquippa Works steam for mill engines, pickling, heating, etc., has heretofore been supplied from stoker-fired boilers, burning coke breeze and some coal, operating at 150 lbs. pressure. These normally developed about 5,000 bhp. Steam for operating the turbo-generators located at this point has been supplied from boilers using waste heat from rectangular coke ovens and operating at 200 lbs. pressure. These developed normally about 10,000 bhp., a total of about 15,000 bhp. which, with immediate and contemplated development, would soon be inadequate.

The waste-heat boiler plant has given satisfactory service for a number of years, but the abandonment of these coke ovens and the replacement of their capacity with by-product ovens renders the boilers no longer of use, as they are not set or arranged in a way to permit of adapting them to satisfactory coal firing.

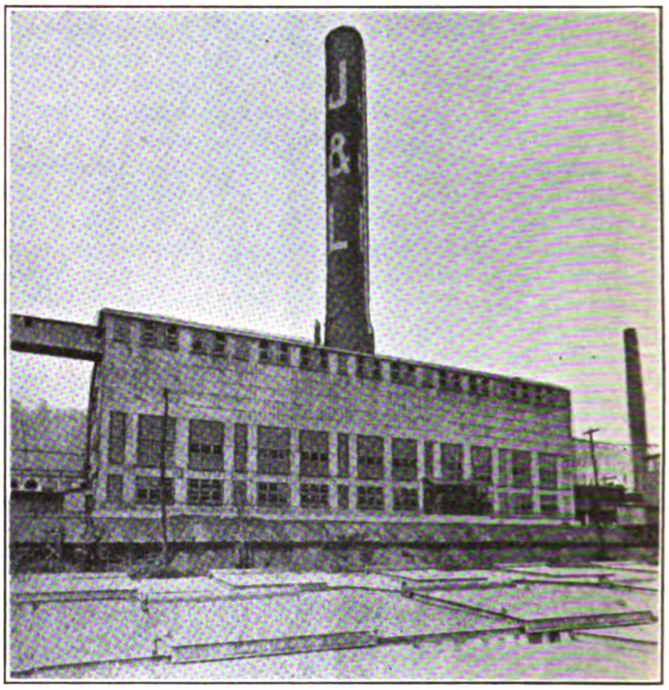

FIG. 1—View of power house.

After considering all the alternatives, it was decided to construct a thoroughly modern boiler plant which would completely replace the waste-heat plant and limit the stoker-fired plant to burning such coke breeze as might be available. Equipment was sought which would be simple, reliable and which would embody the latest proved developments in the art, produce the highest economic result, and be of a design which could readily take advantage of such improvements as might become available in the future.

The electric power plant equipment is capable of using steam at 225 lbs. gauge pressure and 120 deg. superheat. In order to deliver this pressure to the turbines and thus secure the maximum efficiency of which they are capable, boilers were purchased for a working pressure of 250 lbs. gauge and provided with superheaters to give the desired total steam temperature. A pressure reducing and desuperheating system is provided, through which steam from this boiler plant may be fed into the 150-lb. system when the available coke breeze is not sufficient to produce the low pressure steam demand.

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*Paper delivered at meeting of American Iron and Steel Institute, New York, October 28.

†Chief engineer, Jones & Laughlin Steel Corporation, Pittsburgh, Pa.

A site was available convenient to the river coal hoist and near the generating station where the bulk of the steam from the new plant will be used.

Study of the present steam demands and consideration of probable developments in the near future indicated the desirability of providing a developed boiler capacity of about 20,000 hp. The available space for boiler house construction was such that this capacity could be secured through the installation in a single row of five boilers of 1,900 nominal hp. to operate normally at about 200 per cent of rating. As the plant is constructed, there is space for the future installation of two more boilers, one at each end of the boiler house.

Pulverized fuel firing was chosen as embodying the best modern practice, lending itself to future development and producing an economic operating result. Unit type pulverizers with air register type burners though not quite as high in efficiency as the central pulverizer plant system, cost somewhat less and with the low cost of coal prevailing at this plant were figured to produce, including fixed charges, a lower over-all steam cost.

Successful operation with the rates of combustion contemplated requires adequate cooling of furnace walls in order to prevent serious slagging and scouring. The vertical bent tube type boiler lends itself to this system in that the boiler tubes form the upper rear of the furnace and a portion of the front row of tubes may be so extended down and over the rear wall as to leave no unprotected brickwork at the rear of the furnace. The type and general arrangement of boilers is shown in Fig. 2.

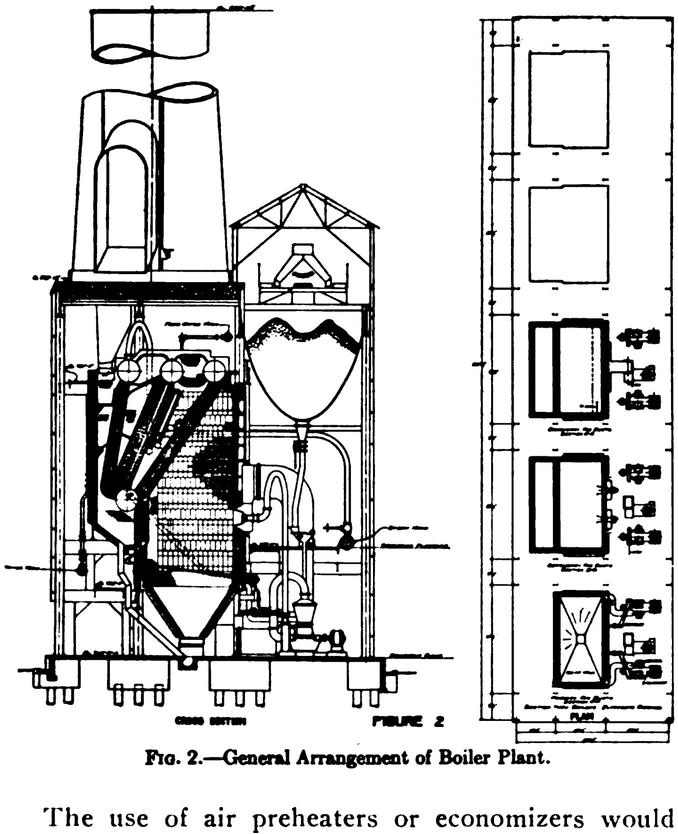


Fig. 2.—General Arrangement of Boiler Plant.

The use of air preheaters or economizers would improve the boiler plant efficiency but with the low fuel cost the improvement in efficiency would not produce sufficient saving to return a satisfactory profit on the additional investment involved.

To assure complete combustion the furnaces were designed for a maximum heat liberation of about 25,000 Btu. per cu. ft. per hr., requiring 10,300 cu. ft. of combustion space. The front and side walls are hollow and are cooled by drawing air for combustion through them.

Pulverized fuel burners use a current of air for transporting the pulverized coal to the burner and into the furnace. The air so used which is not sufficient for complete combustion is called "primary air," and is drawn through the hollow walls of the ash hoppers accomplishing the double purpose of cooling the hoppers and providing hot primary air. The air required in excess of the primary air is drawn through the furnace front and side walls, as noted above, and delivered to the burners by individual fans, and is called "secondary air."

Each boiler is provided with two a.c. motor-driven unit type pulveriziers and two burners having a combined capacity of 20,000 lbs. of coal per hour which is sufficient to run the boiler at about 320 per cent of rating. One pulverizer and burner can be operated to produce from 75 per cent to a little over 150 per cent of boiler rating. This broad range in rating permits great flexibility in plant operation.

Draft sufficient to secure the maximum ratings at which it is desired to operate the boilers is provided by a self-supporting natural draft stack, 250 ft. in effective height and 20 ft. in diameter. The stack is of steel, brick-lined and superimposed upon the center of the building structure. An insulated steel flue runs longitudinally along the roof directly above the boiler damper openings and veritcal uptakes conduct the gases into it from the boilers. This stack is of sufficient size to handle the gases from seven boilers at 300 per cent of rating.

Coal is conveyed from the main mill receiving and crushing plant to the boiler by an inclined belt conveyor, and delivered directly into an overhead suspended steel bunker having a capacity of 2,000 short tons, sufficient to operate the boiler plant for about 40 hours. Chutes leading from the bunker to each pulverizer are provided with gates which may be operated by chains from the operating floor. (See Fig. 2.)

The feeders which regulate the flow of crushed coal to the pulverizers are also located at the operating floor level, as are the other controls for operation of the boilers.

Ash from the furnaces and rear of the boilers is discharged periodically into a hydraulic sluiceway running the length of the boiler plant to a pit outside at the end of the building. Refuse is accumulated in this pit and removed from time to time to standard gauge car by locomotive crane. Operation to date has indicated that about 15 per cent of the ash is caught in the hopper, so that 85 per cent dust passes out of the stack.

The feed water, a mixture of condensate and treated river water, is heated with the exhaust steam from a 750-kw. house turbine located in the power plant, augmented when necessary by steam bled from the main generating units. The feed water mains are in duplicate and form a loop.

A single steam header is provided connecting at one end to the generator station and low pressure system. There is no loop or connection from the other end, it being thought that duplication for emergencies with the necessary numerous valves to make it effective would carry possibilities of trouble which the simpler construction would avoid.

The building is of steel frame construction, sheathed with corrugated iron and supported upon a pile foundation. The boilers are hung from the building steel so that no separate foundations or steel work are required for them. The side facing boiler fronts is provided with ample window area thus securing natural light during daylight hours.

In designing the plant the main considerations were simplicity, ease of operation and an efficiency commensurate with the low fuel cost. Operations incident to handling the boilers and furnaces are confined to the operating floor. The pulverizers themselves require very little attention during operation and their location on the basement floor permits dismantling and repairs without interference with boiler operation. Platforms are provided connected by stairways from which all valves can be operated and all normal operating functions carried out. Monorail hoists are provided over the pulverizers and their driving motors to facilitate repair work.

Tests made during March indicate the following operating efficiencies:

100 per cent rating	79 per cent
150 per cent rating	79 per cent
200 per cent rating	78 per cent
250 per cent rating	76 per cent

The foundation for this installation presented a puzzling and interesting problem. It had been the intention to use spread foundation directly on top of the slag filling which is some 15 ft. deep at this point. The ground drillings show some 20 ft. of mushy clay under this slag, and below that, about 25 ft. of sand and gravel to bed rock.

Had the site been well removed from the river bank, it is possible the construction might have been carried out as first planned, but in this location the river bank being near, it was feared that the soft material might be pushed out.

As it was considered impracticable to drive piles through slag, it was at first believed it would be necessary to excavate to the clay, drive concrete or wooden piles to gravel, capping them with a re-inforced concrete mat to distribute the heavy concentrated loads, in some cases as high as 800 to 1,000 tons.

The rectangular ovens which were very close to the site would have to be shored up and kept in operation. This we considered both an expensive and risky procedure. The work on this narrow site, lying between the railroad tracks and the rectangular ovens with the generating station at one end, must be entirely handled from one narrow end. All the excavated material must be removed through this neck and piling and equipment with concrete material for the mats brought in the same way, a slow, expensive process.

As against this, the scheme which was adopted was that of pipe piling; consisting of driving 16-in. O.D. pipe the full distance of 60 or 65 ft. through slag, clay, sand and gravel to rock, cleaning out the same and filling with concrete. This enabled us, by using the allowable loading of 100 tons per pile, to greatly reduce the number of piles, save a considerable amount of money in the cost of the excavation and reinforced mats, avoid all risk to the rectangular coke ovens, and to have the foundations ready in much less time than otherwise would have been possible.

As time was a vital element in this job, the type of foundation adopted proved very fortunate in speed of execution as well as in cost and quality of design. The job containing some 158 piles, each 64 ft. long, a total length of about 10,000 ft. of 16-in. pipe was driven, cleaned out and concrete-filled with sufficient foundation caps to allow the steel erection to start 43 days after starting the driving of piles, virtually no excavation being necessary, as the ground level was a few feet below floor level.

The general speed of the work was excellent. The engineering contract for designing the plant was signed May 14, 1926. Foundation work was started June 30. First structural steel was set August 12. First boiler was put in operation November 22. The entire plant was ready for service early in January, 1927, about 250 days after signing the engineering contract, and slightly over six months after work started on the site.

To Install Continuous Tunnel Kilns in All Silica Brick Plants

The progressive attitude of Harbison-Walker Refractories Company in adapting the latest scientific improvements to its own manufacturing processes is well-known throughout the industry. And now it assumes even greater significance through the decision of the company to install continuous tunnel kilns in five plants, variously situated, which are at present engaged in the production of silica brick.

The plans call for ultimate displacement of all old round-type periodic kilns, thus marking the most important advance in the industry since its inception. The reconstruction of the East Chicago Works alone, the first to be affected, involves an expenditure of some $1,500,000, and from this may be judged the far-reaching importance attached by Harbison-Walker executives to their decision.

At this point it might be well to take note of the fact that the continuous tunnel kiln method is not new in the burning of refractory materials. A number of manufacturers employ it today in the production of ordinary fire-clay brick, and, in fact, the Harbison-Walker people were the first in the industry to experiment with the process. The extremely high temperature required to burn silica brick, however, has been a barrier in this particular practice which has precluded the adoption of the method up till the present time.

The interesting progress of this important phase of Harbison-Walker history dates back to a visit made to Dusseldorf, Germany, by J. E. Lewis, president of the company, together with O. M. Reif and Nin McQuillen, vice presidents. There, in the plant of the Heinrich Koppers Company, they investigated the practicability of a continuous tunnel kiln for the burning of silica brick on a commercial basis. After thorough investigation they found that the kiln functioned perfectly with German rawstock and German methods, but it remained to establish definitely its adaptability to American refractories practice.

In order to prove this beyond the question of a doubt, several hundred tons of ganister rock, the rawstock for silica brick, were shipped overseas to Dusseldorf and actually made up into American type brick under the direct supervision of representatives from the Harbison-Walker technical and operating staffs. The result of these exhaustive tests is that Harbison-Walker Refractories Company has secured exclusive rights for the Koppers type kiln in the United States and is now actually installing the first unit in its East Chicago plant.

Cold Rolling Mill of Recent Design

A Special Design of Electrically Driven Mill of Six Units Which Offers Several Distinct Advantages Especially in the Manufacture of Bolts and Nuts

By E. W. DUSTON

MANUFACTURERS of bolts and nuts purchase the round wire in coils which is fed into bolt headers that cut it and upset the heads, making the bolts automatically out of cold metal up to 5/8 in. diameter. They manufacture nuts on automatic nut machines which are capable of making hex or square nuts up to 5/8-in. bolt size from metal in the coil. On larger sizes the metal is in bar form.

Purchasing the metal in coils from the hot mills means that the manufacturer of nuts must purchase and carry in stock a great many sizes of round bolt stock and as many sizes of nut stock which in many cases means a very large invoice of material.

On account of the nut stock coming from the hot mill this means that the orders must be placed far in advance to receive good attention, of fairly good proportion, and further the tolerance of the hot rolling is greater and the price higher than in rounds. Owing to these conditions and the demand for stock of accurate sizes, the E. W. Bliss Company, of Brooklyn, N. Y., has developed at its plant in Salem, Ohio, a special nut stock mill, designed to roll nut stock from round rods or wire. A brief description of this machine follows:

The machine consists of six units with individual motor drive for each one. The first unit is a 10-in. flat mill; the second unit is an edging mill; the third unit is an 8-in. mill; the fourth is another edging mill; the fifth unit is an 8-in. mill, and the sixth and last unit is a Take-up Reel or Block.

The round wire enters the first mill and is flattened and in going through the passes is rolled into the various sizes and shapes and is wound up on the traverse winder at the rate of 200 to 400 ft. per minute. Thus it delivers a bundle of uniform size that can be easily fed into a nut machine and eliminates the trouble of breaking tools which is so common with hot rolled stock.

Some of the advantages of rolling nut stock from rounds are that several sizes may be rolled from one diameter. Rounds may be secured more easily than flat stock. The amount of stock carried may be reduced one-half to one-third. Many times it happens that a hurried order for nuts is received with no stock on hand to fill the order. The result is, the mill is set up for the required size and the nuts are rolled from the round wire, thus supplying the nut department with a clean, bright material of accurate size without annealing or pickling.

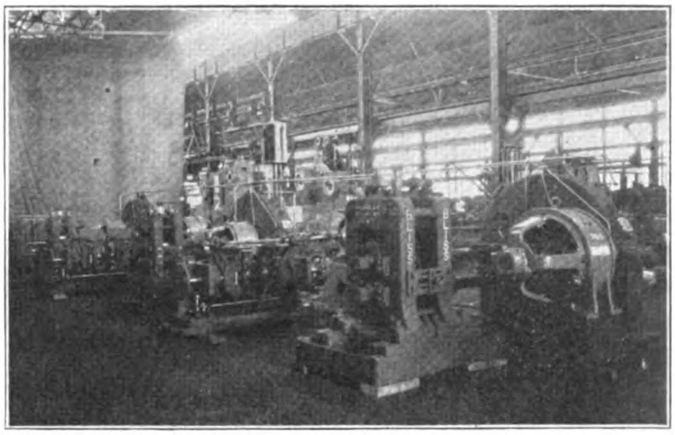
The mill can always keep ahead of the nut machines. Much breakage of nut tools is caused at the first and last end of a coil. By this process, owing to elongation of wire by rolling and starting with larger coils, bundles may be obtained which will require very much longer to make up, thus reducing breakage.

The machine has a capacity for handling 1 in. down to 3/16 in. diameter. While it was primarily built for nut stock it can also be used for rolling hex or square. It can also be used for rolling flat material such as brake bands and other strip metal having square or other shape edges.

The electrical equipment is arranged as follows:

The five roll stands and coiler are each driven by independent motors or adjustable speed, having a range of two to one.

The controller comes under the Clark Patent, of which the E. W. Bliss Company, has exclusive license.



Mill as assembled.

These patents cover the electrical control which is so arranged that each of the mills following the first mill will automatically adjust their speed to the speed of the bar going through the stands. This speed is accomplished by putting a tension in the strip being rolled.

The mill is set up so that each mill runs about 10 per cent faster than the previous one. In threading up the machine the operator pushes the threading-in button which means that all mills start up and run at a speed which is approximately one-tenth of the normal speed of the mills.

After the bar has been entered into all of the stands and is attached to the reel, the operator presses the second button and all motors simultaneously increase the speed at which they have been set to run; namely, anywhere from 200 to 400 ft. per minute, at the finishing stand.

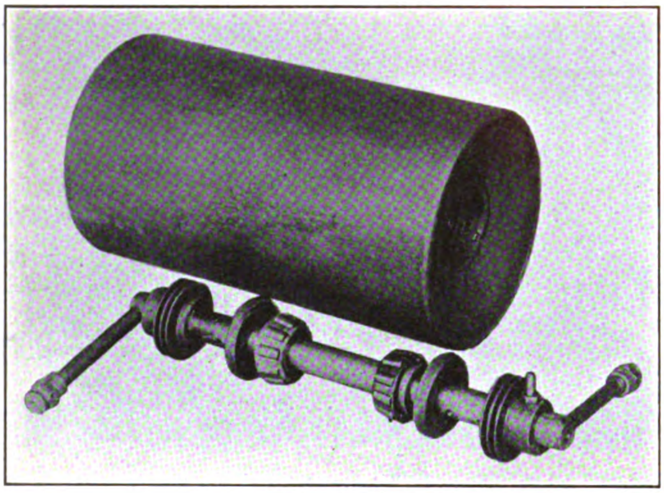
In general, the action of converting or shaping a round into a rectangular section the elongation amounts to about 20 per cent to 30 per cent depending on size and shape.

In regard to the labor required, two men are sufficient for operating.

WITH THE EQUIPMENT MANUFACTURERS

New Type of Belt Conveyor

The Stephens-Adamson Manufacturing Company has recently placed on the market a new type of belt conveyor carrier which embodies several improvements both in construction and design. The new carrier is known as the Stephens-Adamson Simplex carrier, the complete line including carriers for belts ranging in width from 12 to 60 in. The carrier proper consists of three rollers in line, the troughing rollers being mounted at a 20 degree angle in order to increase the capacity of the belt. The carriers are mounted on a heavy steel angle section base, which is self cleaning. The whole assembly is tilted slightly in the direction of belt travel, in order to facilitate the proper training of the belt.



The rollers are self contained units, of very simple, but strong construction. They are made of steel tubing, and are furnished with drawn steel end plates. The ends of the rollers are rounded to protect the belt from fraying, or wear. Each roller is equipped with two Timken Bearings, the method of mounting the bearings being as follows: The cones, or lower races, are pressed onto the roller shaft and located by a washer. The cups are pressed into a steel tube which forms the roller axle, and are located by shoulders in the tubes. The bearings are protected from dust and other foreign substances by a combined labyrinth washer and multiple groove grease seal. The permanent adjustment of the bearings is provided for by lock screws.

Lubrication of the rollers is of the high pressure grease variety. Each roller shaft is equipped with two high pressure fittings, one at each end, which project far enough to make them readily accessible. The shaft has drilled passages, which connect the fittings with the interior of the tube in which the bearings are mounted, the latter serving as a reservoir for the lubricant. A space has been left between the bearings and the outer closure, into which grease is forced by the pumping action of the bearings themselves, hence an even distribution of the lubricant is obtained. By virtue of these arrangements, it is only necessary to supply lubricant to the bearings at infrequent intervals.

All the parts of the carriers, such as bearings, shafts, rollers, brackets, and complete roller assemblies are mutually interchangeable for belts of the same size.

Chrome Base Plastic Cement

In metal-melting and heating furnaces, boiler furnaces, cement and lime kilns and other refractory structures, the highly heated brick work is subjected to the corrosive action of fuel ash and furnace products containing iron oxide, lime, magnesia, alkalies, etc. These basic oxides attack the siliceous fire brick and flux away their surfaces at temperatures far below the true softening point of the fire brick.

Grefco is exceptionally plastic and readily lends itself to either dipped or trowelled joints. Its softening point lies between 3400 and 3500 deg. F. Owing to its non-shrinking characteristics and ability to adhere to brickwork, Grefco forms a working surface of chrome refractory which protects the brick against the fluxing action of basic substances and materially prolongs the life of the brickwork.

Refractory structures such as electric furnaces, combustion chambers in oil, gas and powdered coal installations, coal gas retorts, etc., which are subject to rapid failure can be effectively repaired and kept in continuous operation by patching with Grefco. The material is either rammed in place or preferably applied with a cement gun. For heavy patching and monolithic work, Grefco can be mixed with Grefco Chrome Grog or with crushed fire-brick.

Grefco is a product of the General Refractories Company, Philadelphia, whose research laboratory and technical staff will be glad to be of service to the refractory user interested in prolonging brick life.

Totally Enclosed Motors for Portable Hoists

General Electric announces a new line of motors for portable electric hoists and suitable also for other applications involving intermittent operation and high starting torque. The line runs from 1 to 10 hp. in the d.c. type; from 1 to 11 hp., single speed, 3 and 2 phase, and from 1 to 5 hp., single phase, in the a.c. types. Three and two-phase, slip-ring type hoists motors are also included from 3 hp. up.

The new motors are totally enclosed and all parts are well protected. Bearings are of the waste-packed, sleeve type, being closed against the entrance of dirt from the outside. The d.c. motors are series wound. The a.c. motors of the polyphase type have high-resistance rotors, while the single-phase motors have an unusually high starting torque.

In a great many of the applications of these motors a brake is required. Accordingly the motors are all built with the shaft extension away from the drive to take a brake, and the motor end-shield at this end is fitted with pads or bosses with drilled and tapped holes for mounting the brake.

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Link-Belt Exhibit at Power Show

Link-Belt Company will exhibit in spaces 677, 678 and 679 on the fourth floor of Grand Central Palace.

Products shown will be the Sykes Herringbone Speed Reducer, Vibrating Screen, the new Link-Belt Anti-Friction Belt Conveyor Idler, the Caldwell Speed Reducer, the Caldwell Car Spotter, Link-Belt Silent Chain and other Drive Chains.

In addition, our representatives will give information on the following Link-Belt products—the Peck Carrier, Coal Crushers, Feeders, Car Dumper, Locomotive Crane, Crawler Crane, Portable Loaders, Water Intake Screen, Power Hoe, Skip Hoist and other Coal and Ashes Handling Equipment.

H. J. Kiely, Harry Strube, Frank Webster, C. A. Woerwag, Geo. L. Morehead and Frank B. Caldwell will attend the exhibit.

Renewable Tooth Sprocket

The present day trend toward greater economy in all phases of manufacturing finds rather unique expression in a Renewable Tooth Sprocket for chain drives, as designed and produced by The Union Chain and Manufacturing Company of Sandusky, Ohio.

These sprockets are furnished either split or solid, though the latter are most generally used due to the permanent nature of the installation, as once they are installed their life is measured only by the life of the plant or the machine.

Further data on this economical sprocket may be had by writing direct to the above company.

Iron and Steel Division National Meeting

The newly formed Iron and Steel Division of the American Society of Mechanical Engineers was authorized at the society's spring meeting in White Sulphur Springs.

Mr. Roy C. Brett, the organizing chairman of the division and also chairman of the Cleveland Section that sponsored the formation of the division, announces the first national meeting will be held in Youngstown, Ohio, on November 10. Mr. C. Snelling Robinson is chairman of the Youngstown committee on arrangements.

The meeting will be of one day duration with two outstanding technical papers in the morning, plant inspection tours in the afternoon and an informal dinner in the evening.

The meeting will be one of joint co-operation with various sections of the A.S.M.E. and Engineers Clubs in iron and steel localities.

PROGRAM

Headquarters: Hotel Ohio

9:30 A. M.—Registration. Mezzanine floor, Hotel Ohio.

Information about inspection tours should be secured when registering and also secure tickets for the evening dinner.

10:15 A. M.—Technical session. Banquet room, mezzanine floor.

Presiding officer: E. T. McCleary, vice president, Youngstown Sheet & Tube Company, Youngstown, Ohio.

Super-refractories—C. M. Phelps, director of research and tests, refractory fellowship, Mellon Institute, Pittsburgh, Pa.

Developments of four-high rolling mills—F. C. Biggert, Jr., member, president, United Engineering & Foundry Company, Pittsburgh, Pa.

1:30 P. M.—Inspection tours.

6:30 P. M.—Informal dinner. Banquet room, mezzanine floor.

Toastmaster: C. S. Robinson, member, vice president, Youngstown Sheet & Tube Company, Youngstown, Ohio.

Speakers: Charles M. Schwab, president, American Society of Mechanical Engineers, and chairman of board, Bethlehem Steel Corporation, New York City; J. A. Campbell, president, Youngstown Sheet & Tube Company, Youngstown, Ohio; Alex Dow, member, president, Detroit Edison Company, Detroit, Mich.

Plant inspection tours—Youngstown Sheet & Tube Company, Campbell Works; Republic Iron & Steel Company; Truscon Steel Company; Carnegie Steel Company, Ohio Works; General Fireproofing Company.

COMING MEETINGS

Nov. 9-10—Industrial Commission of Ohio. Safety conference and exhibits, Columbus, Ohio. J. M. Woltz, chairman of metal section, Youngstown Sheet & Tube Company, Youngstown.

* * *

Nov. 7-12—Automotive Accessories Association. Second annual show, Armory at Sixteenth Street and Michigan Avenue, Chicago. William B. Levey, manager, 1107 Standard Life Building, Pittsburgh.

* * *

Nov. 10—National Meeting, Iron and Steel Division of American Society of Mechanical Engineers, Ohio Hotel, Youngstown, Ohio. C. S. Robinson, chairman, 714 Stambaugh Building, Youngstown, Ohio.

* * *

Nov. 16-17—National Founders Association Convention, Hotel Astor, New York City. Secretary, J. M. Taylor, 39 South LaSalle Street, Chicago, Ill.

* * *

Nov. 17-18—Personal Research Federation, Hotel Pennsylvania, New York City. Director, Col. Walter V. Bingham, 40 West Fortieth Street, New York.

* * *

Nov. 19—International Conference on Bituminous Coal, Carnegie Institute of Technology, Pittsburgh, Pa.

* * *

Dec. 5-8—Annual Meeting, American Society of Mechanical Engineers, Engineering Society Building, New York City. Secretary, Calvin Rice, 29 West Thirty-ninth Street, New York.

* * *

Dec. 5-8—Sixth national exposition of Power and Mechanical Engineering, Grand Central Palace, New York City. Manager, Fred W. Payne, Grand Central Palace.

TRADE NOTES

The stockholders of the Farrel Foundry & Machine Company and the stockholders of the Birmingham Iron Foundry, at a meeting held recently, voted unanimously in favor of merging the two companies. The newly formed company will be known as the Farrel-Birmingham Company, Inc., and will have the following officers and directors:

President, Charles F. Bliss; vice presidents, F. D. Wanning, Walter Perry, Franklin Farrel, Jr.; secretary, George C. Bryant; assistant secretaries, Carl Hitchcock, W. B. Marvin; treasurer, Alton Farrel; assistant treasurer's, F. M. Drew, Jr., Donald G. Warner.

The capital of the new company will be $5,700,000.

The original products—power drives and gears, are still manufactured, but the company today devotes itself chiefly to the service of the five basic industries—metal-rolling mills, rubber mill machinery, paper calenders and sugar mill machinery.

* * *

The Brown Instrument Company announces the opening on September 1, 1927, of a Kansas City branch at 509 Mutual Building, Kansas City Mo. Mr. F. M. Poole will be district manager of this branch.

* * *

The Timken Roller Bearing Company of Canton, Ohio, and Mr. M. B. U. Dewar of London, England, have, together, purchased from Vickers, Limited, all of the capital stock of British Timken, Limited. This purchase gives Timken complete control, througout the world, of the manufacture and sale of Timken bearings.

Mr. Dewar, who now assumes active management of British Timken affairs, was until recently managing director of The Metropolitan Carriage, Wagon & Finance Company, Ltd., of Birmingham, England, a corporation with a capital of $50,000,000 and he was also a member of The Industrial Management Board of Vickers, Ltd.

The Birmingham plant of British Timken, Ltd., is being enlarged, and large quantities of new machinery and equipment have been installed. Officials of British Timken, Ltd., are now at the Canton, Ohio works making final arrangements for the immediate establishment of factories in France and Germany.

Formerly the British Timken, Ltd. has been operating for many years under license from The Timken Roller Bearing Company. Its products are used in 55 makes of British touring cars, 32 makes of motor trucks and buses, eight makes of motorcycles, and are incorporated in the parts, such as rear axles, front axles, trailer axles, and disc wheels, made by eight different parts manufacturers. The applications in the passenger cars and trucks include front and rear wheels, differentials, pinions, steering pivots and transmissions.

* * *

International Combustion Engineering Corporation announces the closing of a contract by its subsidiary, Combustion Engineering Corporation with the Kansas City Power & Light Company for two complete steam generating units for the Northeast Station. Each of these units will deliver 250,000 lbs. of steam per hour continuously.

The boilers are designed for 1,400 lbs. pressure, which is said to be the highest operating pressure in use today. The contract includes Lopulco Unit Systems for burning pulverized fuel, water-cooled furnaces, economizers and air preheaters, all manufactured by Combustion Engineering Corporation.

This contract closely follows one awarded to Combustion Engineering Corporation in August for the Grand Avenue Station of the Kansas City Power & Light Company, covering three units of 225,000 lbs. capacity, complete with stokers, and, designed to operate at 700 lbs. pressure.

Forty boilers are now installed at the Grand Avenue Station. The three new units are to have a total steaming capacity equal to more than half that of the entire existing plant.

* * *

The Bailey Meter Company of Cleveland, Ohio recently moved into its new quarters at 1050 Ivanhoe Road, where approximately three times as much floor space is available as exists in the old plant on East Forty-sixth Street.

The rapid growth and development in the field for metering and combustion control equipment as well as the leading part which the Bailey Meter Company has played in this field has necessitated their moving into larger quarters on three different occasions since 1916 in order to keep pace with the demand for Bailey products. The main offices of the company and the manufacturing plant are now located at the Ivanhoe Road address.

* * *

Robert June—Advertising, of Detroit, announces that in order to extend and improve facilities of the organization, they are moving from the building formerly occupied at 2208 West Grand Boulevard, to the General Motors Building. The organization, comprised of engineers, and which has specialized for some years in industrial advertising, now includes national advertising in the scope of its service.

* * *

At Burnside, on the South Side of Chicago, the American Brake Shoe & Foundry Company has owned and operated for many years a well arranged and well equipped iron foundry. This plant has just been purchased by the American Manganese Steel Company, to make a seventh of the chain of foundries extending from Delaware to California, producing Amsco Manganese Steel Castings. The date set for beginning operations at Burnside under Amsco management is January 1, 1928, although this may occur somewhat sooner.

* * *

The American Engineering Company of Philadelphia, announces the appointment of Mr. George L. Drake as agency sales supervisor for its Lo-Hed hoist division.

* * *

For the convenience of customers in the Cleveland district, the Rollway Bearing Company, Inc., has opened a sales office at 956 Leader Building, Cleveland, Ohio. Mr. R. D. Faris has been appointed Cleveland district representative and will make his headquarters at the above address.

NEWS OF THE PLANTS

The dry process ore reducing plant at the National Tube Company, Lorain, Ohio, is nearing completion and operations are expected to start November 1. The granular iron from the new plant will be pressed into briquettes and then refined in open-hearth and electric furnaces.

* * *

The Youngstown Sheet & Tube Company, Youngstown, Ohio, has placed a contract with the Koppers Company, Pittsburgh, for 71 by-product coke ovens and a coal handling plant for installation at the South Chicago works. Construction of the group will cost about $3,000,000. With the additional 71 ovens the company will have in operation a total of 688 by-product coke ovens.

* * *

Definite assurance of the intention of six Ohio sheet steel companies to consolidate has been given by officials of the interested companies. Those companies entering into the consolidation are the Ashtabula Sheet Steel Company, Empire Steel Company, the Falcon Steel Company, the Mansfield Steel & Tin Plate Company, the Thomas Sheet Steel Company, and the Waddell Steel Company. Combined these plants will have an annual capacity of 380,000 tons of black sheets and plates, which is the possible output from the 60 mills under control. Until a full appraisal of the various plants has been made details as to the financial arrangements and personnel of the new organization will be withheld.

* * *

The Allegheny Steel Company, Brackenridge, Pa., has purchased the plant of the Delaware Seamless Tube Company, Auburn, Pa.

* * *

The Leatham D. Smith Stone Company, Sturgeon Bay, Wis., has disposed of its large quarries and plant to the Dolomite Company, Cleveland, Ohio, for a consideration said to be $675,000. The latter company will take possession January 1 and is planning extensions to cost $200,000.

* * *

Announcement is made of a $15,000,000 consolidation of producers of sheet metal products, involving the Steet Metal Products Company, Toronto, Ont., the McClary Manufacturing Company, London, Ont., and the Thomas Davidson Manufacturing Company, Montreal, Que. The new consolidation will be known as General Steel Wares, Ltd.

* * *

The Tioga Steel & Iron Company announces the suspension of operations at its Philadelphia plant. All manufacturing activities formerly conducted there will hereafter be performed at the plant of William Wharton, Jr., & Company, Inc., at Easton, Pa., an affiliated organization. Removal of equipment will take place without interruption of business and it is expected that the consolidation will be completed by October 31. The move is being made to secure economies in operation and improvement of service.

At the annual meeting of the stockholders of the Philadelphia and Reading Coal and Iron Company held at the general office of the company, Reading terminal, Philadelphia, today, Andrew J. Maloney was elected president and the following directors: Robert J. Cary, Robert J. Montgomery, George H. Campbell, Joseph Wayne, Jr., Newton H. Fairbanks, Leon E. Thomas.

Andrew J. Maloney, the new president of the Philadelphia and Reading Coal and Iron Company, is vice president and sales manager of the Chicago, Wilmington & Franklin Coal Company of Chicago.

Mr. Maloney, a native of the anthracite fields of Pennsylvania and for 25 years one of the leading figures in the bituminous industry, succeeds W. J. Richards, who resigned the presidency of the company on June 30.

* * *

The Robert W. Hunt Company, engineers, inspection and tests, Chicago, wish to announce that the location of their Birmingham office is now in the Bankers Bond Building, Birmingham, Ala.

The Nation's Welfare and Manganese

The recent organization of the American Manganese Producers' Association in Washington, comprising companies, corporations, and individuals from almost every section of the United States, and of which J. Carson Adkerson of Woodstock, Virginia, is president, has focused attention on one of the most important sources of national wealth, not only because of the intrinsic value of the mineral involved, but because of the fact that manganese is absolutely indispensable in the nation's welfare.

The American Manganese Producers' Association is co-ordinating its resources and co-operating its efforts to make the United States independent of foreign sources of supply for its needs. It is spending hundreds of thousands of dollars in developing mines and processes for the beneficiation of ferruginous ores with which to supplement the supply of high grade ores being produced, or in reserve. It is fighting for the life of the industry against concessionaires who have invested huge amounts in manganese mines in Russia. It is striving for the independence of the United States, in time of war and stress, in creating a supply of the mineral from American mines to meet national emergencies.

The development of the manganese reserves of the United States has come through the placing of a small import tax on manganese, which amounts to but 16 cents per ton in the cost of steel, and is negligible when passed on to the consumer. Its repeal would mean the wrecking of an industry in its infancy and one of immeasurable importance in the country's weal.

In over twenty States of the Union manganese development is going on and the association is firm in the belief that the nation's needs will be considered paramount to foreign interests and that such protection as is needed will be afforded domestic producers of manganese.

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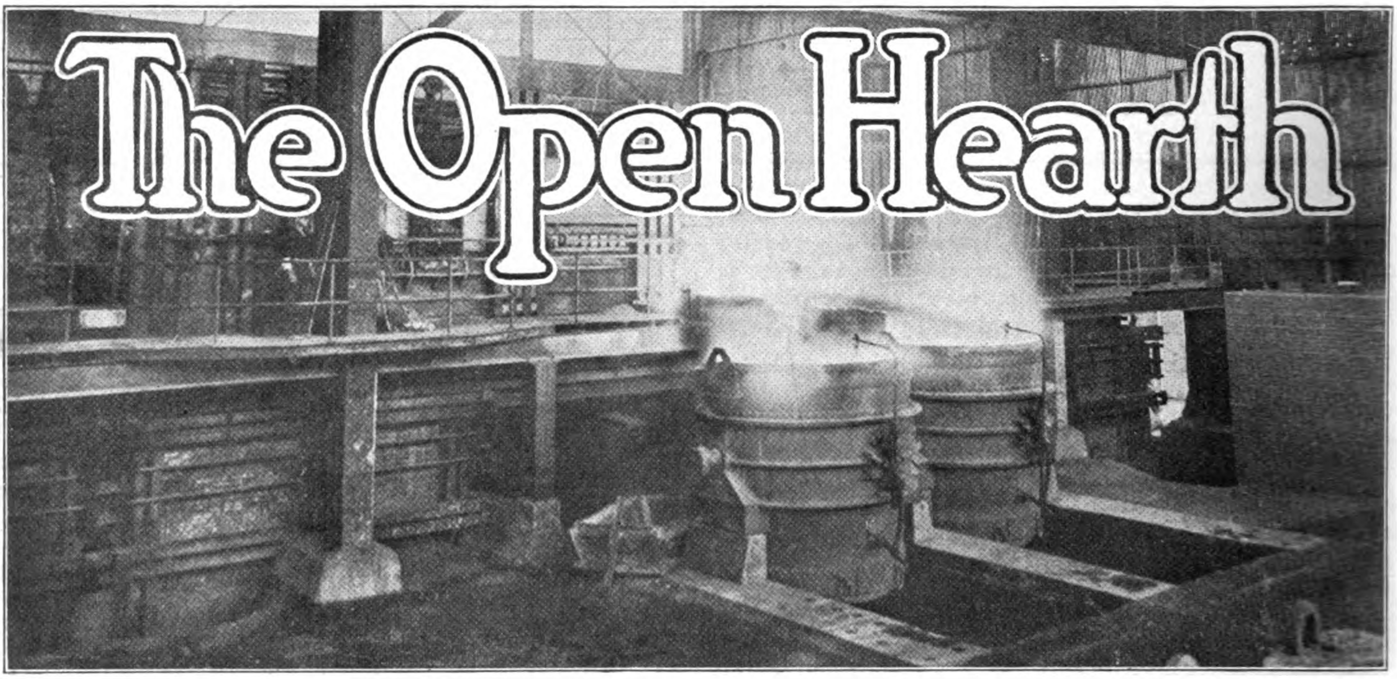
The Open Hearth



Mr. Walter Sennhauser formerly mechanical engineer for Sulzer Brothers, Ltd., Winterthur, Switzerland arrived in New York on September 26 and will act as chief engineer of the Dry Quenching Equipment Corporation. This corporation, which is a subsidiary of the International Combustion Corporation, will promote the dry quenching of coke as now practiced extensively abroad and to a small extent in this country. Mr. H. D. Savage is president of the Dry Quenching Equipment Corporation and Mr. George E. Leonard is chairman. Mr. Sennhauser will have headquarters in the International Combustion Building at 200 Madison Avenue, New York City.

* * *

R. S. Kerns, for some time in charge of the metallurgical research and instructor in metallurgy, Pennsylvania State College, State College, Pa., has accepted the position of sales engineer for the Acheson Graphite Company, Niagara Falls, N. Y. Mr. Kerns served as a helper on a 10-ton open-hearth furnace at the Cambria Steel Company, Johnstown, Pa., early in his career.

* * *

J. A. Lannigan has been made works manager of the Sharpsville, Pa. and Hubbard, Ohio plants of the Valley Mould & Iron Corporation.

* * *

Walter Springe who has represented the Heine Boiler Company in the Kansas City and St. Louis territories for the past 25 years has been recently appointed district manager of Combustion Engineering Corporation for this district. Mr. Springe has been prominently identified with the sale of power plant equipment for many years and is well known throughout the states included in his territory. R. J. Robinson has been appointed as branch manager, under Mr. Springe at St. Louis.

* * *

Charles E. Shearer, for several years advertising manager for the Industrial Works, Bay City, Mich., has resigned, effective October 20. No announcement has yet been made as to his future connection.

* * *

Mr. E. H. Haslam has recently been made district manager of Elliott Company's Chicago district office. His early work was with Mackintosh-Hemphill & Company of Pittsburgh, designers and builders of steam engines, rolling mill machinery, and other equipment used in iron and steel work. With this company Mr. Haslam worked up from draftsman to chief engineer, vice president and general manager. In 1920 he went with the Steel & Tube Company of America where his duties included the supervision of all engineering as well as new construction. When this company was merged with the Youngstown Sheet & Tube Company Mr. Haslam resigned to take up consulting work in Chicago. For a few years he served as superintendent of the Pittsburgh works of the Pressed Steel Car Company. He is a member and for a time served as director of the Engineering Society of Western Pennsylvania. He is also a member of the A.S.M.E. and the Iron and Steel Institute.

* * *

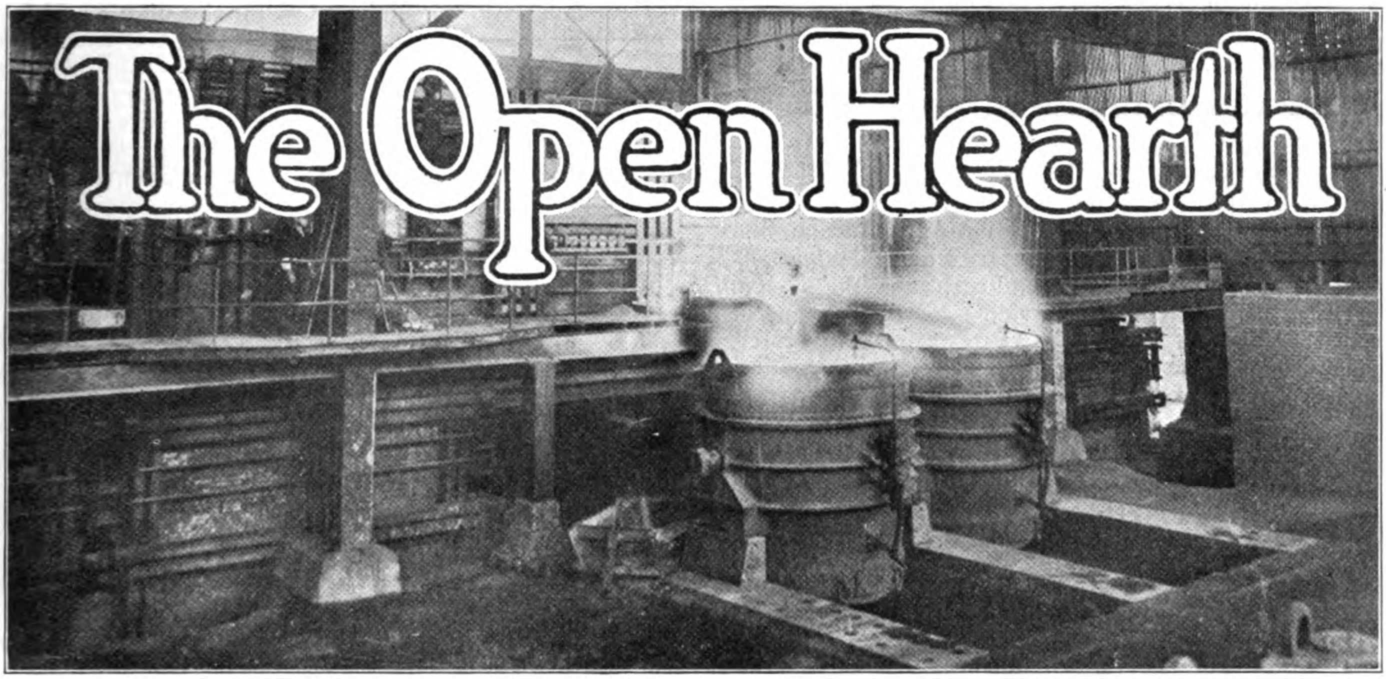
E. R. O'Neil, formerly open-hearth superintendent of the Otis Steel Company, Riverside Plant, Cleveland, Ohio, has resigned and accepted a similar position with the Columbia Steel Corporation, Pittsburg, Cal.

* * *

Fred J. Fisher, one of the founders of the Fisher Body Company, Detroit, and Clearence R. Bitting, managing director of the Fisher Company, will become members of the board of the Baldwin Locomotive Works, Philadelphia. They will be elected as soon as pending legal procedure has been completed.

* * *

Harrison Souder has resigned as general manager of the Bethlehem Mines Corporation, Cornwall divi-



sion, Lebanon County, Pa., effective October 1. He is now located at Ridgewood, N. J.

* * *

Gregory J. Cornstock, director of research for the Firth-Sterling Steel Company, sailed on a six weeks' trip to England, where he will spend some time in the research department of Thomas Firth & Sons, Sheffield. He will visit various English and continental steel and cutlery plants.

* * *

R. Edson Emery, recently president of the Superior Steel Corporation, Pittsburgh, has been made vice president of the Colonial Steel Company, Pittsburgh. Before becoming associated with the Superior Corporation he was for 22 years with the Crucible Steel Company of America. When he left that company he became Pittsburgh district mill manager, in charge of LaBelle, Singer-Nimick, Park and Crescent works in Pittsburgh and the Norwalk works, Norwalk, Ohio.

* * *

E. K. Miller, who was superintendent of the Bessemer, Ala., blast furnaces of the Tennessee Coal, Iron & Railroad Company, is now superintendent of the company's new furnaces under construction at Fairfield, Ala. His successor at Bessemer is G. M. Harris, who has been assistant superintendent of the Bessemer furnaces. J. A. Meissner, assistant superintendent of the company's Alice furnace at Birmingham, has been transferred to Bessemer where he succeeds Mr. Harris.

* * *

Mr. H. R. Harris, 1123 Metropolitan Life Building, Minneapolis, Minn., has just been appointed as representative of The Falk Corporation of Milwaukee, Wis., manufacturers of herringbone gears, speed reducers, and flexible couplings. Mr. Harris will cover the state of Minnesota and also Douglas County, Wisconsin.

* * *

Mr. H. K. Gowdy has recently joined the Elliott Company organization, as sales engineer in the Boston territory. Mr. Gowdy was a student apprentice with Westinghouse, and was chief engineer of the Homer Street Power Plant of the Newton & Boston Street Railway. Later he was chief engineer of the Connellsville plant of the West Penn Power Company, superintendent of power plants for the Pittsburgh Railways, and chief steam engineer for the Cambria Steel Company at Johnstown. He also has conducted a private consulting practice, specializing on the rehabilitating of power plants.

* * *

C. A. Reed has been appointed district manager of the Pittsburgh office of the Erie City Iron Works. This appointment became effective October 15. Mr. Reed has had a wide experience in the power plant field having been with the Green Engineering Company for two years and with the Combustion Engineering Corporation for six years. He is a graduate of the University of Wisconsin. Offices will be maintained at 1230 Park Building, Pittsburgh.

* * *

Carl G. Werscheid has joined the Colonial Steel Company, Pittsburgh, as assistant district manager of the St. Louis district.

* * *

R. B. Dimmick has been appointed chief metallurgist of the Columbia Steel Company, Butler, Pa., filling the position previously held by N. L. Melville and Robert C. Good. The Columbia Company is now a subsidiary of the American Rolling Mill Company, Middletown, Ohio.

Former Editor Dies

Will Rollins McCord, 52, for some time editor of The Blast Furnace and Steel Plant, died recently at his home in New York City. He was a son of Mr. and Mrs. W. B. McCord and was born in East Liverpool, Ohio.

He was city editor of the old Pittsburgh Dispatch in 1907-9, and was connected with Iron and Steel and The Blast Furnace and Steel Plant, as managing editor until 1915 when he took up publicity work and moved to New York. During his residence in this city he was an active worker in the Pittsburgh Press Club.

TRADE PUBLICATIONS

"The Dry Quenching of Coke" is briefly, but concisely explained in Publication S-1 now being distributed by the Dry Quenching Equipment Corporation, a subsidiary of the International Combustion Engineering Corporation. The text and illustrations make apparent the operation and results of the system —The Sulzer System—as carried out at the plant of the Rochester Gas & Electric Corporation, Rochester, N. Y., where operation was conducted for a considerable period. Economies are listed under a separate heading as are installations. Ten plants are in operation in Europe. The publication can be obtained upon request from the offices at 200 Madison Avenue, New York.

* * *

"Conco" cranes and trolleys are described in a 43-page catalogue compiled by H. D. Conkey & Company of Mendota, Ill. The equipment is for service where comparatively light tonnages are handled in structural shops, power plants and boiler works. The catalogue is well illustrated and contains much descriptive matter.

* * *

Oxwelded Roof Trusses is the title of a publication edited by H. H. Moss, of the Engineering Department of the Linde Air Products Company. It is a study of insert plate joints in Fink type roof trusses. The 69-page booklet is really a text book on the construction of roof trusses, with special reference to that construction in which the connections are welded. The information is purely technical and will undoubtedly prove of much interest to structural engineers.

* * *

"Stop Corrosion" is the title of a publication mailed by the Witt-Humphrey Steel Company of Greensburg, Pa. It explains a method of protecting articles of steel and iron by covering them with a coating blown in a molten spray at a velocity of about 3,000 ft. per second. The Witt-Humphrey Company also fabricates steel plate construction work of all kind.

* * *

The properties of Agathon Enduro Stainless Irons are interestingly set forth in a 4½ x 7½-in. booklet edited by the Central Alloy Steel Corporation of Massillon, Ohio. The steels described are those of such a composition that they will resist rust, scaling and corrosion. Besides giving the chemical and physical properties of the various steels, considerable space is devoted to matters of general interest in connection with the manufacture of steel, its heat treatment, etc. Copies may be obtained by addressing the corporation at Massillon.

* * *

"The Most Economical Method of Burning Coal" is the title of a new bulletin just published by the Detroit Stoker Company. The bulletin outlines the factors to be considered in selecting fuel burning equipment, with a brief discussion of the several points. The various types of Detroit stokers, including Multiple Retort Rear Cleaning for large boilers requiring high duty; Double Retort Side Cleaning Stoker for medium boilers; Single Retort Stoker, Side Cleaning, for small to medium boilers of 100 to 300 hp. each; the Unistoker, which is a modification of the single retort side cleaning stoker, having the motor and fan attached as a single independent unit; and Industrial Stokers for all services, are illustrated. The bulletin should be of special service to consulting engineers and executives considering power plant extensions. It is known as Bulletin No. 979. Copies may be had by addressing the Detroit Stoker Company, 979 General Motors Building, Detroit, Mich.

* * *

Leaflet 3907-C of the Westinghouse Electric & Mfg. Company decribes turbines for mechanical drive in capacities 5 to 750 brake hp. They are admirably suited for driving circulating pumps, centrifugal boiler feed pumps, blowers and other rotary apparatus either directly or through the medium of reduction gears. The leaflet contains a number of illustrations together with descriptive information of the turbines.

* * *

The second issue of the "Demag News" is an interesting specimen of technical journalistic literature. The first article "Cranes for Harbor Construction" deals with the various special cranes designed for this type of work and is explained by means of drawings and numerous illustrations. These cranes are fully described and amongst them the 400-ton floating crane for constructing the harbor in Bari, Italy, is specially mentioned. The second article deals with the gasification of coke for generating producer and water gas, clearly indicating that this method of utilizing coke has proved particularly advantageous and economical in gas works.

The additional articles refer to roller straightening machines, underground electric compressors traveling on rails, small bundling presses for sheet metal scrap, stock line indicators for blast furnaces, self-discharging wagons for metallurgical works, lamellar hooks and new workshop cranes. Finally, a report on the reconstruction of a rolling mill in which extensive alterations to the sheds were carried out without disturbing normal working, is particularly noteworthy.

Condenser and Stokers for Brooklyn Edison Plant

The Brooklyn Edison Company has recently placed an order with the Westinghouse Electric & Mfg. Company for a single-pass surface condenser which when installed will be the largest of its kind in the world. This huge apparatus is necessary to condense the exhaust steam from the 147,500 hp. turbo-generator to be installed in the Hudson Avenue generating station during 1928. The condenser will contain 14,400 brass tubes with a total surface area of 85,000 sq. ft.; if placed end to end the tubes would form a single tube 71 miles in length. East River water will be circulated through the condenser at the rate of 135,000 gal. per minute.

Another large order which the Edison Company has recently placed with the Westinghouse Electric & Mfg. Company covers the furnishing of four mechanical stokers which will be used in connection with 2400 hp. boilers. The stokers will be of the latest underfeed type, equipped with electric driving motors, grinders to dispose of the ash.

Each stoker will be capable of burning approximately 20 tons of bituminous coal per hour without objectionable smoke, and which will enable the boiler when thus fired to generate 350,000 lb. of steam at 400 lb. per square inch pressure.

THE STEEL PLANT BRICK MASON

A Section Devoted to Items of General Interest to Blast Furnace and Steel Plant Brick Masons

Harbison-Walker Acquires Walsh

The Harbison-Walker Refractories Company of Pittsburgh, through an exchange of stock, has acquired the Walsh Fire Clay Products of St. Louis, Mo. The Walsh plant at Vandalia, Mo., the largest in the St. Louis field, with its daily capacity of some 150,000 9-in. fire brick thus increases the capacity of Harbison-Walker, already the world's largest producer of refractories, by approximately 10 per cent.

Few makers of fire brick are more widely known than the Walsh Fire Clay Products Company, one of the oldest producers in the St. Louis district, and incidentally the largest. Its plant has within recent years been completely modernized with the introduction of continuous kilns and the most modern type of clay working machinery.

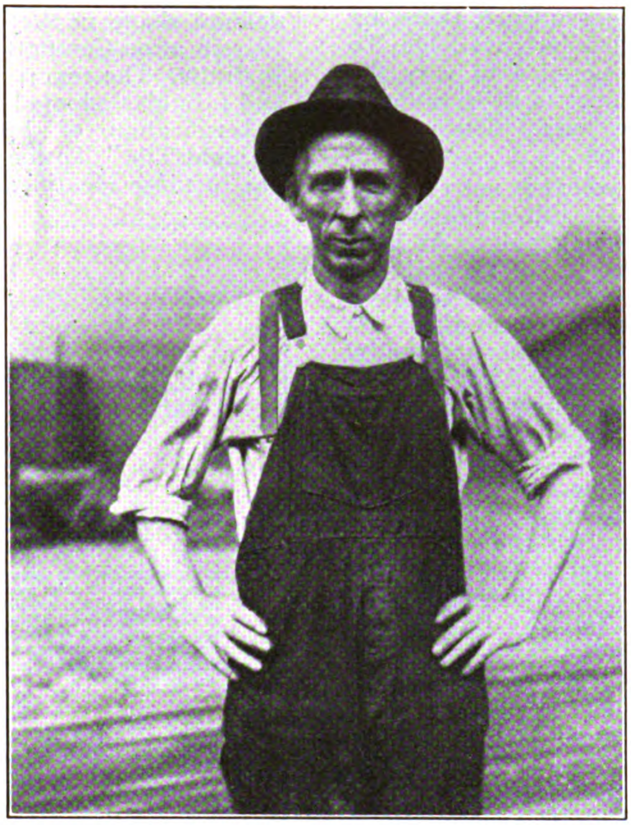
Harbison - Walker has hitherto had no plants West of the Mississippi. This development rounds out its production to include all the major fields of the ceramic industry.

Rate of Heating and Softening Point of Refractories

Softening point tests were carried out on a number of refractory materials, including fire clay, silica, and silica cements, in a gas-fired furnace. The rate of heating up to cone 28 was varied from 1 to 5 hrs. Long heating did not appreciably lower the softening point of fire clays. With silica bricks the 1½ hr. rate gave the highest results; longer heating reduced the softening point. Results with silica cements were erratic. Variations in softening temperature were reduced by fine grinding and intimate mixing of the materials; the purer the material the less the softening point varied.

Paper on Spalling

"The Significance of the Elasticity and Thermal Expansion of Fire Clays with Reference to the Spalling of the Fired Product" is the title of Technologic Paper No. 4 recently issued by the American Refractories Institute. The paper is edited by R. F. Geller, Chief Refractories Section Bureau of Standards.



At the Benwood Plant of the Wheeling Steel Corporation, John F. O'Brien has served in the brickmason department for 37 years. Today he is superintendent of this department and is also president of the Quarter Century Club composed of 204 members.

Properties of Some Special Refractories*

By M. F. Beecher

Mullite is a compound normally produced artificially in the electric furnace. It consists of three molecules of alumina combined with two of silica. The fusion point of alumina taken alone is 2,050 deg. C. (3,720 deg. F.), the fusion point of silica about 1,700 deg. C. (3,090 F.), while the fusion point of mullite is 1,810 deg. C. (3,290 deg. F.) A further observation is interesting with respect to this compound, which is, that in normal clay refractories, heating to a high temperature or continued heating over long periods of time at temperatures above 1,200 deg. C. (2,190 deg. F.), converts the silica and alumina originally present into the crystalline mullite which is found distributed as discrete but small crystals throughout the body of the ware. Additional mullite continues to form as the temperature or time of heating is increased until all of the alumina has been so combined; because all fireclays and kaolins contain excess silica over that required to combine with the alumina present in the formation of mullite. So in this material we have in some particulars the normal stable end product produced by prolonged heating of the usual clay refractory.

Mullite is not produced by nature in amounts of sufficient quantity to be of any commercial interest. It is made artificially by fusing a composition of silica sand and bauxite, or silica sand and alumina in an electric arc furnace of the same type as that used for producing fused alumina. A product high in mullite content (75 to 85 per cent) which is recently finding quite extensive use is made by calcination at high temperatures of such minerals as sillimanite, andalusite and cyanite. These minerals have the composition $Al_2O_3.SiO_2$, hence the calcined product contains an excess of silica which is present as glass.

Fused alumina is known under several brand names, such as "Alundum," "Aloxite," "Borolon," etc. It is normally produced in two general grades or qualities.

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*Abstract from paper delivered at convention of American Society for Steel Treating, Detroit, September 23, 1927.

For the brown or regular "Alundum" grade of fused alumina the raw material used is bauxite to which is added the proper amount of iron borings and coke in order to effect the desired degree of purification during smelting. The purer, or No. 38 "Alundum" grade, is produced by the straight fusion of precipitated alumina resulting from the chemical treatment of bauxite.

Fused alumina finds its principal field of usefulness in the abrasive industry. But it also has many properties which particularly commend it for use as a refractory. The electric furnace product consists of crystalline, artificial corundum together with a small amount of slag or accessory constituents. The abrasive characteristics can be varied to a marked extent by changing the size or physical structure of the crystals or by changing the kind or amount of the slag or accessory constitutents. As a consequence, there are varied types of fused alumina abrasives available. To a somewhat lesser extent it is possible to vary the physical and chemical characteristics of fused alumina in order to change the refractory characteristics which it contributes to the finished shape.

Silicon carbide is a material which is not supplied by nature but is the discovery of Dr. Edward G. Acheson. It has no melting or softening point. At high temperatures, that is at 2,250 deg. C. (4,080 deg. F.) it dissociates readily into the elements silicon and carbon. At lower temperatures beginning at about 800 deg. C. (1,470 deg. F.) it begins to oxidize appreciably. Between 1,000 and 1,200 deg. C. (1,830-2,190 deg. F.) the oxidation is fairly rapid. At temperatures above 1,200 deg. C. (2,190 deg. F.) one of the results of this oxidation is the development of a viscous coating which serves automatically to protect the silicon carbide and greatly retards the progress of oxidation. Above this temperature, therefore, silicon carbide protects itself quite satisfactorily and becomes a very useful refractory. In order to increase the temperature range of usefulness and also to improve this normal protective coating which is formed, it is common practice for manufacturers to apply a glaze or relatively impervious coating to all silicon carbide shapes in order to retard the destruction of the refractory from this cause.

Silicon carbide is known under such trade names as "Crystolon" and "Carborundum." It is produced in electric furnaces of the resistance-type and is principally used as an abrasive, but because its chemical and physical characteristics particularly fit it for refractory work, its use in this field is rapidly increasing.

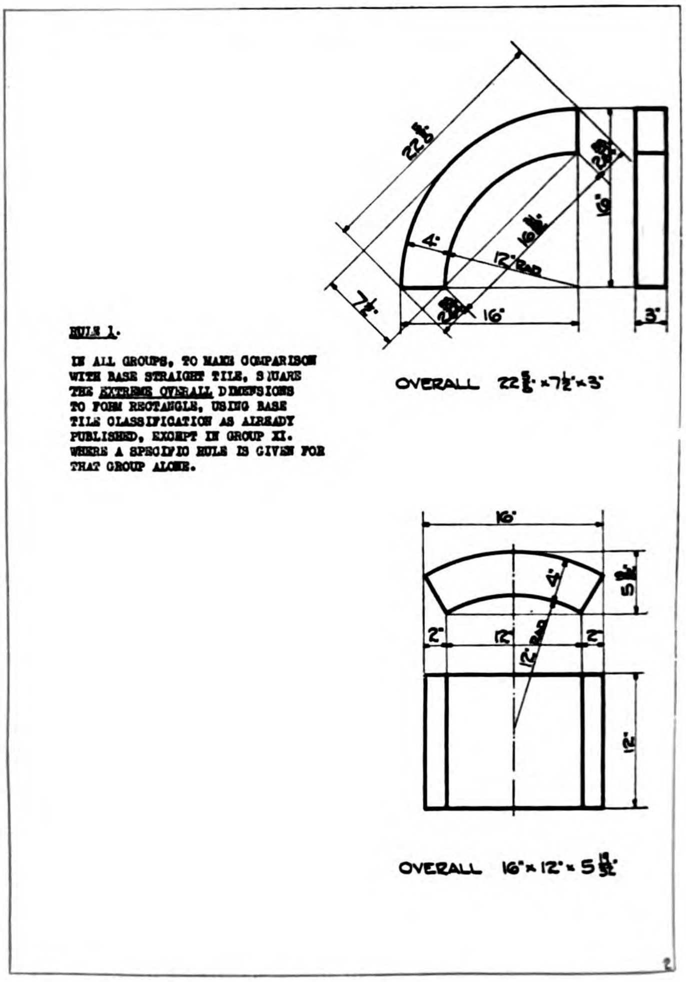
Silicon carbide is a chemical compound of silicon and carbon and has the formula SiC.

Official Classification of Fire Brick Shapes Now Available

The history of the refractories industry has not been unlike that of many others insofar as "trade secrets" are concerned. As in glass manufacture, where individual formulae were carefully guarded as valued secrets in order to insure exclusiveness of product, so in the making of fire brick, where methods of production and of determining costs have played an all-important part in the profit or loss on any particular order which involved other than standard shapes. The individual manufacturer's methods were strictly "private property," to be cherished as a birthright, and the prerogative prevailed throughout the industry.

It is not necessary to analyze here the change of heart which has come over American industry since those pre-war days of secretiveness and "closed-door" policies. It is sufficient to recognize that business methods and business relations have steadily become more broadminded, and that business policies, generally speaking, are more of the "open-door" variety. Today, we find certain associations acting as clearing houses of ideas in order to benefit industries as a whole, and we see even life-long competitors revealing manufacturing cost methods to each other—zealous as ever, but no longer jealous.

The renaissance in the refractories industry takes definite shape in the publication of a report by the Classification Committee of the American Refractories Institute. The report is in the form of a set of rules and formulas adopted by the Institute and is entitled "Classification of Fire Clay Shapes Other than Straight Tile." To the layman the title suggests little, but to those identified with refractories procedure in the past, the universal adoption of such a classification code signifies an achievement which marks a turning point in the industry and in which the institute and its committee may well take pride. For this code once-for-all places upon a commonly-accepted basis the methods of determining costs of all special fire brick shapes.



RULE 1.

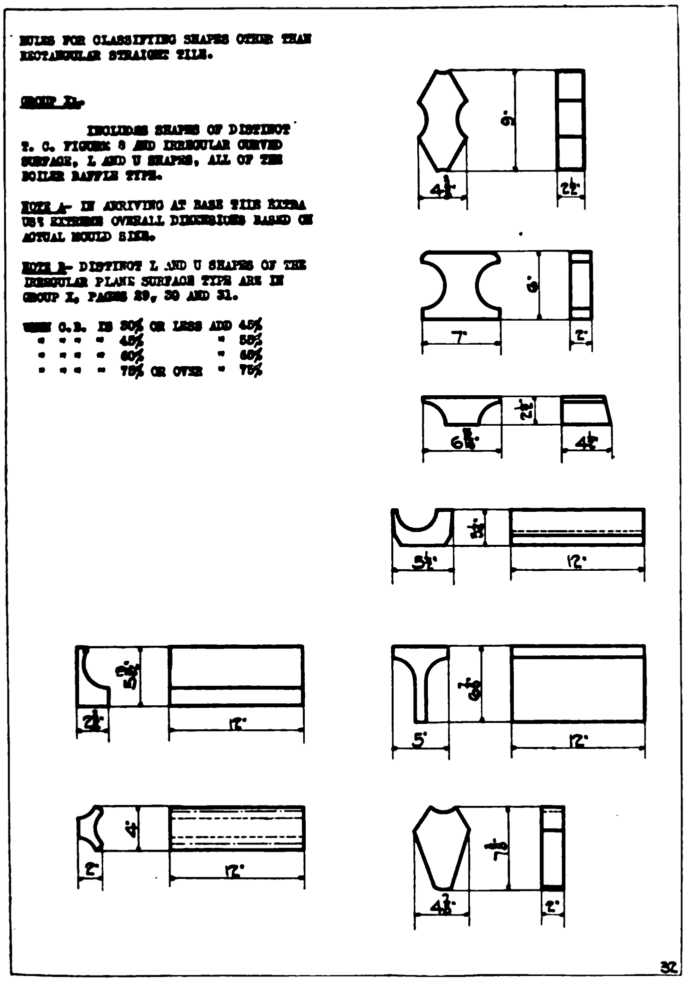
IN ALL GROUPS, TO MAKE COMPARISON WITH BASE STRAIGHT TILE, SQUARE THE EXTREME OVERALL DIMENSIONS TO FORM RECTANGLE, USING BASE TILE CLASSIFICATION AS ALREADY PUBLISHED, EXCEPT IN GROUP XI. WHERE A SPECIFIC RULE IS GIVEN FOR THAT GROUP ALONE.

FIG. 1

This forward step was not effected over night. It is the cumulative result of over 15 years' work of individual members of the Classification Committee, as well as of many months' deliberation of the committee as a whole. The committee, composed of representatives of all important producing areas in the eastern half of the United States, has had free access to the costs of manufacturers in the several producing districts, and its conclusions are thoroughly representative. Therefore, one may presume its report to be inclusive in scope and complete in detail. As a matter of fact, a mere summary of the contents does not convey an adequate impression of the thoroughness with which the work has been completed.

Mechanically, the classification leaves nothing to be desired. Each rule and formula is definitely laid down in easily-understood language, and once it has been established, one or more illustrative examples follow in order to insure its proper interpretation. For instance, Rule 1 deals with the Method of Squaring Irregular Shapes as Shown in Fig. 1.

This is the basic rule for the entire system of classification, and it is logically followed by seven other rules of general character. These cover Volume Reduction, Applying Composite Base, Mould Expense, Quantity Differentials, Over-shipments, Determining 9 in. Equivalent and Disposition of Decimals in Piece Prices.



RULES FOR CLASSIFYING SHAPES OTHER THAN RECTANGULAR STRAIGHT TILE.

GROUP XI.

INCLUDES SHAPES OF DISTINCT T. C. FIGURE 8 AND IRREGULAR CURVED SURFACE, L AND U SHAPES, ALL OF THE BOILER BAFFLE TYPE.

NOTE A- IN ARRIVING AT BASE TILE EXTRA USE EXTREME OVERALL DIMENSIONS BASED ON ACTUAL MOULD SIZE.

NOTE B- DISTINCT L AND U SHAPES OF THE IRREGULAR PLANE SURFACE TYPE ARE IN GROUP X, PAGES 29, 30 AND 31.

WHEN O.R. IS 30% OR LESS ADD 45%
" " " " 45% " 55%
" " " " 60% " 65%
" " " " 75% OR OVER " 75%

FIG. 2

With the eight general rules established, every shape—from the simple arch, key or wedge to the intricate notched and hollow forms—is classified in accordance with 12 distinct groups. As in the case of the general rules, the classification rule is clearly stated for each group, followed again by illustrative examples. Thus we may take Group XI, which is treated according to Fig. 2.

Even from the brief data included here, it readily may be seen how conclusively the code of the Classification Committee fills a need which has long existed, and places the buying and selling of special fire brick shapes upon a sound, scientific basis. There is now no excuse for the manufacturer to lose money on an order for special shapes of fire clay brick, nor the buyer to pay an exorbitant price through ignorance of the production costs.

The Classification Committee's report is typical of the aims and purposes of the American Refractories Institute, which was organized in April, 1925, to take the place of the Refractories Manufacturers Association. The latter was purely a trade association, with its activities largely commercial in character and its membership confined exclusively to manufacturers of refractories. The institute, on the other hand, was founded primarily for scientific ends, with membership open to users as well as makers of refractories, the thought being that the problems of the industry would be more readily solved through discusions in which the producing and consuming views could be expressed. The research activities of the old association through a fellowship at the Mellon Institute of Industrial Research, University of Pittsburgh, have been maintained and enlarged through co-operative efforts with the Bureau of Standards and with colleges having scientific departments.

"Classification of Fire Clay Shapes Other than Rectangular Tile" is now available for distribution to those persons actually indentified with the purchasing of fire brick. Copies may be obtained by writing to the American Refractories Institute, Oliver Building, Pittsburgh, Pa., or to any fire brick manufacturer.

Blast Furnace and Coke Oven Association Meets

An unusually successful meeting of the Eastern States Blast Furnace and Coke Oven Association was held at the Shannopin Country Club, Ben Avon, Pa. on October 7.

Previous to this year the members either indulged in golf or visited a local manufacturing plant before the evening meeting. This year, however, the committee introduced a new feature by instigating round table discussions following the regular luncheon.

These round table meetings were divided into two groups, one concerning blast furnace topics and the other coke oven problems. A questionnaire in which carefully chosen problems were listed for discussion had been prepared for each group, and using this paper as a basis, many vital and interesting questions were discussed which were mutually beneficial to all in attendance.

Mr. C. A. Meissner, chairman of the open hearth, blast furnace and coke oven committees of the United States Steel Corporation, was the speaker at the dinner in the evening. Mr. Meissner's address concerned itself with the recent developments in coal, coke, blast furnace and open hearth practice.

SAFETY FIRST IN THE STEEL PLANT

Section Devoted to the Interest of the Safety Movement

Every Employee to Wear Goggles

A mandatory ruling requiring every employee in an industrial shop to wear goggles while at work was advocated by Harry Guilbert, director of safety of the Pullman Company, in an address before a joint session of the National Safety Council and the National Committee for the Prevention of Blindness held in Chicago, October 14. Addressing safety engineers, industrial physicians, oculists and others concerned with the prevention of blindness who were gathered for the first national conference on this subject, Mr. Guilbert revealed that such a mandatory rule is enforced in all the repair shops and yards of the Pullman Company, and that as a result, the eyes of approximately a thousand of their men have been saved from serious injury or destruction.

Safety Conference on Metals

The industrial commission of Ohio has appointed a committee to formulate plans for a safety conference, and exhibit in Columbus, November 9 and 10. A tentative program has been arranged, and a list of speakers engaged. The morning of the second day will be devoted to sectional meetings, including one designated "metals and foundries."

E. F. Blank is Safety Director for the Jones and Laughlin Steel Corporation. As this corporation has in its employ in normal times approximately 23,000 men there is ample justification for a feeling of pride in the Accident Severity record established.

Steel Plant Papers on Safety

Several very interesting papers bearing on the prevention of accidents in steel plants were read before the sixteenth annual Safety Congress which met in Chicago the week of September 26. Papers that are especially pertinent were Inter-Plant No-Accident Competitions by E. F. Blank of the Jones & Laughlin Steel Corporation; Accident Prevention at Blast Furnaces by Lawrence H. Underwood, superintendent blast furnaces, Youngstown Sheet & Tube Company, and Conducting Safety Meetings by N. V. B. Ziegler, personnel director of the United States Aluminum Company. These papers will appear in coming issues of The Blast Furnace and Steel Plant.

The Religion of the Safety Movement

By Charles Herbert Rust, D.D.

Its origin—It is believed to have begun with the Illinois Steel Company in 1907.

This company decided that crippled men were not necessary products of industry.

Almost simultaneously, other companies thought the same thing.

Representative men from these companies met in Milwaukee in 1912.

They organized the National Safety Council the following year.

Some 60 cities have organized community safety councils.

American industry is becoming more thoroughly organized with 100 per cent accident prevention as the ideal.

It is a scientific humane movement, backed by the best brains of industry.

Its significance is being more and more recognized.

The United States Government is organized for it.

Officers of the National Safety Council

Officers of the National Safety Council: President, H. E. Niesz, of the Commonwealth Edison Company, Chicago; vice president for Industrial Safety, E. W. Beck of the United States Rubber Company, New York City; vice president for Local Councils, C. E. Hill of the New York Central Lines, New York City; vice president for Public Safety, Miller McClintock, of Harvard University; Vice President for Public Relations, C. J. Moore, retired, Longmeadow, Mass.; Vice President for Finance, C. E. Pettibone, of the American Mutual Liability Insurance Company, Boston; Vice President for Membership, H. A. Reninger, of the Lehigh Portland Cement Company, Allentown, Pa.; Vice President for Engineering, G. E. Sanford, of the General Electric Company, Schenectady, N. Y.; Vice President for Education, A. W. Whitney, of the National Bureau of Casualty & Surety Underwriters, New York City; Vice President for Health, Prof. C. E. A. Winslow, of Yale University; Treasurer, G. T. Hellmuth, of the Chicago, North Shore & Milwaukee Railroad Company, Chicago; Managing Director, W. H. Cameron of Chicago.

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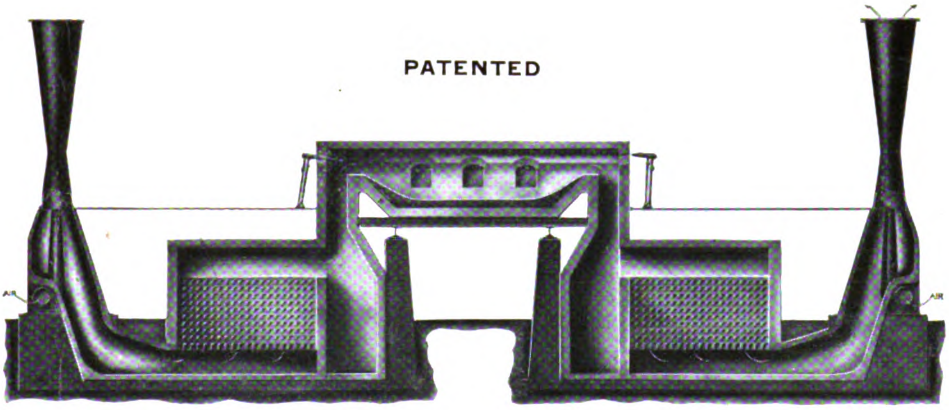

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